53RD ANNUAL FUZE CONFERENCE

"Next Generation Fuzing - Maximum Advantage for the Warfighter"

Lake Buena Vista, FL

19 - 21 May 2009

Agenda

Wednesday, May 20, 2009

GENERAL SESSION

KEYNOTE SPEAKER:
- Mr. Darold Griffin, Engineering Management Executives (EME)

SESSION II
- *DTRA Overview*, Danny Hayles, Defense Threat Reduction Agency
- *ARDEC Overview*, COL Scott Flynn, USA
- *DOE Fuzing and Firing Systems Overview*, Paul Butler and Scott McEntire, Sandia National Lab
- *Navy Overview*, Randy Cope, NAWCWD China Lake
- *Air Force Acquisition Strategy*, Marcelious Willis, Jr., 679th Armament Systems Squadron
- *Fuze IPT Perspective*, Chuck Kelly, OUSD (AT&L)

OPEN SESSIONS
SESSION IIIA
- *Precision Guidance Kit (PGK)*, Anthony Pergolizzi, US Army - AFMO
- *Flight Controlled Mortar (FCMortar)*, Sanford L. Steelman, III, NSWC Dahlgren
- *AURORA A Next Generation Fuzing System*, Laurie John Turner, Thales Missile Electronics Ltd
- *"Pyro-MEMS: Technological Breathrough In Fuzes Domain"*, Renaud Lafont, NEXTER Munitions
- *Guidance Integrated Fuze (GIF), System Development & Testing*, Wayne C. Worrell, III, Naval Surface Warfare Center, Dahlgren Division
- *Wireless Programming Of 40mm Grenade Launcher Ammunition*, Christian Johnsen, Nammo Raufoss
- *M759 30mm Fuze Sensitivity Improvements*, John Geaney, US Army - ARDEC
- *Fuze Redesign for M67 and Anti-Structure Munition (ASM) Grenade*, Dr. Carl Campagnuolo, US Special Operations Command (US SOCOM)
- *Joint Programmable Fuze Emulation*, 2Lt Jack Wiese, USAF - 679 ARSS
- *Future Fuzing: New Operational Needs And Fuze Technical Challenges*, Max Perrin, JUNGHANS
- *A Strain Gage Based Projectile Health Monitor And Salvage*, Ronald G. Lundgren, Applied Research Associates

Thursday, May 21, 2009

OPEN SESSIONS
SESSION IVA
- *High Fuze Reliability Today And In The Future*, Frank M. Kienzler, JUNGHANS microtec GmbH
- *Dual Function Fuze DM173 For Cartridge 120mm HE*, Martin Leonhardt, JUNGHANS microtech GmbH
- *Development Of A Hard Target Void Sensing Fuze for High Mechanical Shock Load Applications*, Perry A. Salyers, L-3 Fuzing & Ordnance Systems
- *Development of a General Purpose Data Recorder for Very High Mechanical Shock Load Applications*, Marc A. Worthington, L-3 Fuzing & Ordnance Systems
- *Development of Electronic Time Fuze For Self-Propelled Long-Range Howitzer*, Seong Hun Kim, HANWHA Corporation
- *A Robust Planar Triggered Sparkgap Switch for High Power Pulse Applications*, Dr. Thomas A. Baginski, Auburn University
- *A New Generation of High-Shock Accelerometers With Extreme Survivability Performance*, Randy Martin, Endevco Corporation

- *Piezoelectric Power Supply For Medium Caliber Ammunition*, Hege Jodahl, FFI

OPEN SESSIONS
SESSION VA

- *Design And Fabrication Of Small-Sized Radar- Radiometer Sensors With A Single Antenna Configuration in W-Band For Sensor-Fuzed Systems*, Dr. Wan-Joo Kim, Agency for Defense Development
- *BGA Technology In High-G Environments*, Stephen Redington, PE, US Army - ARDEC
- *Inertial Igniters With Programmable Safety Features For Small Thermal Batteries For Munitions Fuzing*, H.L Nguyen, Omnitek Partners, LLC
- *MEMS Impact Sensor*, Dr. Daniel L. Jean, Naval Surface Warfare Center - Indian Head Division
- *High Voltage Multilayer Ceramic Capacitors For High Pulse Current Applications*, John Rogers, Vishay Intertechnology Inc.
- *Hazards Of Inappropriate Fuzing Design*, Lars-Erik Pettersson, Life Time Engineering AB
- *Variable Acceleration Profiling And Characterization Of S&A Escapement Mechanisms*, Dr. Michael A. Deeds, Naval Surface Warfare Center - Indian Head Division
- *MEMS Shock Sensor Field Results Using Alternate Packaging*, Robert D. Sill, PCB Piezotronics Inc.
- *Dent Block Acceptance Test Susceptibility*, Robert Savoyski, Technical Ordnance, Inc.
- *Intelligent Fuzing For Penetrating Munitions: Experiments And Analysis Of Representative Configurations*, Jean-Marc Sibeaud, DGA - Centre d'Etudes de Gramat
- *Explosive Train for XM1158 40mm Proximity Fuze*, Charles Scott Lyon & Timothy M. Mohan, US Army ARDEC

NDIA
National Defense Industrial Association

Event # 9560

PROMOTING NATIONAL SECURITY SINCE 1919

53rd ANNUAL FUZE CONFERENCE

"Next Generation Fuzing - Maximum Advantage for the Warfighter"



May 19 - 21, 2009

www.ndia.org/meetings/9560

LAKE BUENA VISTA, FL

AGENDA



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HOTEL INFORMATION

***Disney's Coronado Springs* Resort**
1100 West Lake Buena Vista Drive
Lake Buena Vista, FL 32830

Tel: (407) 939-1000
Fax: (407) 939-1001

A limited block of rooms has been reserved at the *Disney's Coronado Springs* Resort. The industry and per diem rate are both $175 single/double occupancy. To ensure the discounted NDIA rate, please make your reservations early and ask for the NDIA room block. Rooms will not be held after Friday, April 24, 2009 and may sell out before then. Rates are also subject to increase after this date. The government per diem rate is available only to active duty or civilian government employees.

ATTIRE:
The proper attire for this conference is business casual or military uniform Class B (or equivalent).

INQUIRIES:
For more information, contact Michelle Hariston, Associate Director at (703) 247-9478 or via e-mail at mhariston@ndia.org.

TUESDAY, MAY 19, 2009

3:00 pm - 6:30 pm	Onsite Registration
5:00 pm - 6:30 pm	Opening Reception

WEDNESDAY, MAY 20, 2009

GENERAL SESSION

Session I

7:00 am	Onsite Registration/Continental Breakfast
8:00 am	Introduction/Administrative Remarks, *Mr. David Lawson, Chair, Fuze Division* *L-3 Fuzing & Ordnance Systems*
8:05 am	NDIA Opening Remarks *MG Barry Bates, Vice President, Operations* *National Defense Industrial Association*
8:10 am	Keynote Speaker *TBD*

Session II

CHAIR: ERIC ROACH ASSISTANT: RICH JOHNSON

8:40 am	DTRA Overview *Danny Hayles, Defense Threat Reduction Agency*
9:00 am	ARDEC Overview *TBD*
9:20 am	DOE Fuzing and Firing Systems Overview *Paul Butler and Scott McEntire* *Sandia National Lab*
9:40 am	BREAK
10:00 am	Navy Overview *Randy Cope, NAWCWD China Lake*
10:30 am	Air Force S&T Strategy *Tim Tobik, Air Force Armament Laboratory*
10:50 am	Air Force Acquisition Strategy *Maj Jason Schafer* *679th Armament Systems Squadron*
11:10 am	Fuze IPT Perspective *Chuck Kelly, OUSD (AT&L)*
11:40 am	AWARD CEREMONY

WEDNESDAY, MAY 20, 2009

OPEN SESSIONS

Session IIIA

CHAIR: SCOTT POMEROY ASSISTANT: DON SHUTT

1:00 pm	Precision Guidance Kit (PGK) *Anthony Pergolizzi, US Army - AFMO*
1:20 pm	Flight Controlled Mortar (FCMortar) *Sanford L. Steelman, III, NSWC Dahlgren*
1:40 pm	AURORA A Next Generation Fuzing System *Laurie John Turner, Thales Missile Electronics Ltd*
2:00 pm	Pyro-MEMS: Technological Breathrough In Fuzes Domain *Renaud Lafont, NEXTER Munitions*
2:20 pm	Guidance Integrated Fuze (GIF), System Development & Testing *Wayne C. Worrell, III, Naval Surface Warfare Center, Dahlgren Division*
2:40 pm	Wireless Programming Of 40mm Grenade Launcher Ammunition *Christian Johnsen, Nammo Raufoss*
3:00 pm	BREAK
3:20 pm	M759 30mm Fuze Sensitivity Improvements *John Geaney, US Army - ARDEC*
3:40 pm	Consideration Of Projectile Gyro Stability In Developing Fuze Kit Guidance *Chris E. Geswender, Raytheon Missile Systems*
4:00 pm	Joint Programmable Fuze Emulation *2Lt Jack Wiese, USAF - 679 ARSS*
4:20 pm	Void Sensing Fuze *Dale L. Spencer, Kaman Precision Products - Fuzing*
4:40 pm	A Strain Gage Based Projectile Health Monitor And Salvage *Ronald G. Lundgren, Applied Research Associates*
5:00 pm	Future Fuzing: New Operational Needs And Fuze Technical Challenges *Max Perrin, JUNGHANS*
5:20 pm	ADJOURN
5:30 pm - 7:00 pm	GRAND RECEPTION

US ONLY SESSIONS

Session IIIB

CHAIR: TOM BAGINSKI ASSISTANT: FRAN MATTIA

1:00 pm	Direct Write Primary Explosives For MEMS Fuzing *Amy Wilson, US Army - ARDEC*
1:20 pm	Integrating Direct Write Technologies For Explosive Systems *Dr. Brian E. Fuchs, US Army - ARDEC*
1:40 pm	MEMS - Compatible Processing Of Energetic Materials *Alexander S. Tappan, Sandia National Laboratories*
2:00 pm	Greening Of Primary Explosives *Neha Mehta, US Army - ARDEC*
2:20 pm	Hard Target Penetrator Systems - Level Effects On Fuzes... Or, Why Did My Fuze Just Break? *Dr. Jason R. Foley, Air Force Research Laboratory*
2:40 pm	Reverse Ballistics Testing On Hard Target Penetrations *2d Lt Lashaun M. Watkins*, US Air Force
3:00 pm	BREAK
3:20 pm	Development Of A Real-Time, Autonomous Impact Sensor *Dr. Philip Reiner, Stanley Associates, Inc.*
3:40 pm	Design, Test, & Evaluation Of The Lateral Shock Projectile *2d Lt Mitcheal A. Cooksey, Air Force Research Laboratory Munitions Directorate*
4:00 pm	Coupling Guidance And Fuzing Algorithms For Increased Munition Lethality *Dr. Robert R. Bless, Mustang Technology Group*
4:20 pm	High Fidelity, System-Level Modeling Of The Aft-End Components And Fuze Response Within A BLU-109 Penetrator Under Axial And Lateral Loading *John J. Perry, Applied Research Associates*
4:40 pm	Legacy Warhead Fuze Well Structural Integrity *Dennis P. Hancock, USAF AAC/XR*
5:00 pm	Application of System Engineering Methodologies For The Development Of Fuzes *Eric M. Fiore*, ATK - Mission Systems Group
5:20 pm	ADJOURN
5:30 pm - 7:00 pm	GRAND RECEPTION

AGENDA

THURSDAY, MAY 21, 2009

7:00 am Onsite Registration/Continental Breakfast

OPEN SESSIONS

Session IVA

CHAIR: CURT POWELL **ASSISTANT: GABE SOTO**

8:00 am High Fuze Reliability Today And In The Future
Frank M. Kienzler, JUNGHANS microtec GmbH

8:20 am Dual Function Fuze DM173 For Cartridge 120mm HE
Martin Leonhardt, JUNGHANS microtech GmbH

8:40 am TDW's New 2-Inch Penetrator Fuze
Dr. Helmut F. Muthig, TDW GmbH

9:00 am A Modular Vision For Future Target Detection Device Technology
Gary Buzzard, Thales Missile Electronics Ltd.

9:20 am Development Of A Hard Target Void Sensing Fuze for High Mechanical Shock Load Applications
Perry A. Salyers, L-3 Fuzing & Ordnance Systems

9:40 am Development of a General Purpose Data Recorder for Very High Mechanical Shock Load Applications
Marc A. Worthington, L-3 Fuzing & Ordnance Systems

10:00 am BREAK

10:20 am Development of Electronic Time Fuze For Self-Propelled Long-Range Howitzer
Seong Hun, Kim, HANWHA Corporation

10:40 am A Robust Planar Triggered Sparkgap Switch for High Power Pulse Applications
Dr. Thomas A. Baginski, Auburn University

11:00 am TITLE TO BE ADDED
Randy Martin, Endevco Corporation

11:20 am Piezoelectric Setback Generators For Powering Next Generation Of Smart Fuzing
Dr. Alfredo Vazquez Carazo, MICROMECHATRONICS, INC.

11:40 am Piezoelectric Power Supply For Medium Caliber Ammunition
Hege Jodahl, FFI

12:00 pm LUNCH

US ONLY SESSIONS

Session IVB

CHAIR: TELLY MANOLATOS **ASSISTANT: KEN KELLY**

8:00 am MEMS Safe And Arm Verge Escapement Mechanism -- Update 2008
Dale L. Spencer, Kaman Precision Products - Fuzing

8:20 am An Integrated Composite Energetics Packaging System (ICEPS) For Insensitive Munition (IM) Fuzing Applications
Dr. Amish Desai, Tanner Research

8:40 am New Generation Miniature LTCC Flyback Transformers
George A. Slama, NASCENTechnology, Inc.

9:00 am Navy MEMS Micro-Detonator Based Fuze
Dr. Daniel L. Jean, Naval Surface Warfare Center - Indian Head Division

9:20 am Demonstration of the Army's MEMS Safe & Arm In A Large Caliber Projectile
Tim Hoang, US Army - ARDEC

9:40 am Enabling Technologies For Miniature Firing Systems
Charles A. Treu, NNSA Kansas City Plant

10:00 am BREAK

10:20 am Low-cost High-Performance Switches For Advanced Fuzing Needs
Charles A. Walker, Sandia National Laboratories

10:40 am KDI EndFire Proximity Sensor
Robert Hertlein, L-3-Fuzing & Ordnance Systems

11:00 am Extremely Insensitive Detonating Substance (EIDS) Initiation System
David A. Olson, Naval Surface Warfare Center - Indian Head Division

11:20 am Design In Safety
Brad Biggs, Raytheon Missle Systems

11:40 am A Distributed Safety And Arming System With Optically Linked Remote Firesets
Ralph E. Balestrieri, Naval Surface Warfare Center – Indian Head Division

12:00 pm LUNCH

OPEN SESSIONS

Session VA

CHAIR: FRED PIERING ASSISTANT: DAVE LAWSON

1:00 pm — Design And Fabrication Of Small-Sized Radar- Radiometer Sensors With A Single Antenna Configuration in W-Band For Sensor-Fuzed Systems
Dr. Wan-Joo Kim, Agency for Defense Development

1:20 pm — BGA Technology In High-G Environments
Stephen Redington, PE, US Army - ARDEC

1:40 pm — Inertial Igniters With Programmable Safety Features For Small Thermal Batteries For Munitions Fuzing
Dr. Jahangir S. Rastegar, Omnitek Partners, LLC

2:00 pm — MEMS Impact Sensor
Dr. Daniel L. Jean, Naval Surface Warfare Center - Indian Head Division

2:20 pm — High Voltage Multilayer Ceramic Capacitors For High Pulse Current Applications
John Rogers, Vishay Intertechnology Inc.

2:40 pm — Hazards Of Inappropriate Fuzing Design
Lars-Erik Pettersson, Life Time Engineering AB

3:00 pm — BREAK

3:20 pm — Advances In Thermal Batteries For Fuzing
David E. Harney, Advanced Thermal Batteries, Inc.

3:40 pm — Variable Acceleration Profiling And Characterization Of S&A Escapement Mechanisms
Dr. Michael A. Deeds, Naval Surface Warfare Center - Indian Head Division

4:00 pm — MEMS Shock Sensor Field Results Using Alternate Packaging
Robert D. Sill, PCB Piezotronics Inc.

4:20 pm — Dent Block Acceptance Test Susceptibility
Robert Savoyski, Technical Ordnance, Inc.

4:40 pm — Intelligent Fuzing For Penetrating Munitions: Experiments And Analysis Of Representative Configurations
Jean-Marc Sibeaud, DGA - Centre d'Etudes de Gramat

5:00 pm — OPEN

5:20 pm — WRAP-UP AND CONFERENCE ADJOURNED

US ONLY SESSIONS

Session VB

CHAIR: BARRY NEYER ASSISTANT: MARTY TANNEHAUS

1:00 pm — Design & Evaluation Tools For Exploding Foil Initiators
Lt Timothy A. Ager, US Air Force

1:20 pm — G Hardened Precision Inertial Measurement By Application And Processing Of Arrays Of MEMS Inertial Sensors – Part Of An Advanced Penetrator Fuze Design
Martin Tanenhaus, JayMart Sensors

1:40 pm — Distributed Fuzing
Brad Biggs, Raytheon Missile Systems

2:00 pm — Iron Curtain
Chad Green, Artis, LLC

2:20 pm — Extended Area Protection & Survivability (EAPS) ATO Fuze & Proximity Sensor
Mark E. Etheridge, US Army - AMRDEC

2:40 pm — Performance Characterization Of A Lithium Silicon/Iron Disulfide (LiSi/FeS2) Thermal Battery For Joint Use
Paul F. Schisselbauer, EnerSys Advanced Systems, Power Sources Center

3:00 pm — BREAK

3:20 pm — MEMS Fuze For 40mm HEDP Cartridge
Charles Robinson, US Army - ARDEC

3:40 pm — ARDEC Fuze Activities To Support Shoulder Fired Munition Programs
Lloyd D. Khuc, US Army - ARDEC

4:00 pm — Hardened Miniature Fuze Technology (HMFT) Progress
Jefferson K. Oliver, Air Force Research Laboratory, Munition Directorate

4:20 pm — Fuze And Power Army Technology Objective (FAP ATO) – Radio Frequency (RF) And Laser Detection and Ranging (LADAR) Proximity Sensors
Evan A. Young, US Army - ARDEC

4:40 pm — Hard Target Void Sensing Fuze Progress
Wayne Steege, Alliant Techsystems, Inc.

5:00 pm — Universal Smart Fuze For Unmanned Aerial Vehicles And Other Remote Armament Systems
Daniel Vo, US Army - ARDEC

5:20 pm — WRAP-UP AND CONFERENCE ADJOURNED



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DISNEY'S CORONADO SPRINGS RESORT FEATURES:

RESORT RECREATION

- Sand volleyball court
- Health Club and Salon
- Watercraft Rentals
- Bike Rentals
- Jogging Trails
- Nature Trail

RESORT DINING OPTIONS

- The Pepper Market
- Maya Grill
- Cafe Rix
- Rix Lounge
- Laguana Bar

Disney's CORONADO SPRINGS RESORT

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1100 West Lake Buena Vista Drive
Lake Buena Vista, FL 32830

Tel: (407) 939-1000
Fax: (407) 939-1001

For more information on the *Disney's Coronado Springs* Resort, visit www.disneyconventionears.com/coronado

TRANSPORATION

AIRPORT

Orlando International Airport
1 Airport Boulevard
Orlando, FL 32827

LOCAL GROUND TRANSPORTATION:

Disney's Magical Express Transportation picks you up and takes you from Orlando International Airport to the Resort, while their "hands-free" luggage service delivers your bags from the plane directly to your room. Departing is also a breeze with in-hotel boarding pass service and return shuttle to Orlando International.

Reservations are required. We recommend you make your reservations at least 30 days in advance.

FREQUENTLY ASKED QUESTIONS...

- How do I make a reservation for *Disney's Magical Express* Service?

  If you already have confirmed your room reservations, call 1-407-827-6777.

- Can I book transportation upon arrival at the airport?

  No. You must book your *Disney's Magical Express* reservation prior to arrival to fully benefit from the service and take advantage of complimentary luggage delivery to your Resort room.

- Where is the pickup location for motor coach transportation at the airport?

  You will be directed to the Disney Welcome Center located on Level One in Terminal B.

- What are the hours of operation for the Disney Welcome Center at the airport?

  The hours are 6 a.m. to 11 p.m., but those hours will be extended to meet the flights of all guests who have booked *Disney's Magical Express* service, even if a flight is scheduled to arrive after 11 p.m. The Welcome Center will also closely follow arrival information for flights that may be delayed.

- When will my luggage arrive in my room?

  Your luggage will be delivered after you check into the resort, however you do not need to be in your room at the time of the delivery. Bellman gratuities have already been covered and are not required from our guests for inbound *Disney's Magical Express* luggage service.

SPONSORSHIP OPPORTUNITIES AVAILABLE

CONTINENTAL BREAKFAST SPONSOR (AVAILABLE TO 2 SPONSORS) - $7,500

ONE SOLD TO KAMAN PRECISION PRODUCTS

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- SIGNAGE OUTSIDE THE PARTICULAR EVENT SPONSORED
- SPONSOR RIBBON ON BADGES

COFFEE AND SODA BREAK SPONSOR (AVAILABLE TO 4 SPONSORS) - $4,000

ALL SOLD TO L-3 FUZING & ORDNANCE SYSTEMS

LUNCH SPONSOR (AVAILABLE TO 2 SPONSORS) - $6,000

ONE SOLD TO DSE, INC.

- THREE COMPLIMENTARY SYMPOSIUM REGISTRATIONS
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- SIGNAGE OUTSIDE THE PARTICULAR EVENT SPONSORED
- SPONSOR RIBBON ON BADGES

RECEPTION SPONSOR (AVAILABLE TO 2 SPONSORS) - $10,000

ONE SOLD TO ATK

- FOUR COMPLIMENTARY SYMPOSIUM REGISTRATIONS
- OPPORTUNITY TO DISTRIBUTE LITERATURE ON A TABLE AT REGISTRATION
- PLACEMENT OF YOUR COMPANY'S LOGO IN THE AGENDA HANDOUTS AND PROCEEDING
- SIGNAGE OUTSIDE THE PARTICULAR EVENT SPONSORED
- OPPORTUNITY TO GIVE 10-MINUTE COMPANY PRESENTATION AT THE RECEPTION
- SPONSOR RIBBON ON BADGES

GENERAL SESSION MEETING OPENER (AVAILABLE TO 1 SPONSOR) - $10,000

Disney's version of the Star Spangled Banner is spirit lifiting, emotionally charged rendition that will bring the audience to their feet. Originally arranged by renowned composer David Clydesdale for the United States' historic rededication of the Statue of Liberty, this is a unique patriotic experience designed to motivate your group of guests. This is performed live by a professional Disney vocalist, accompanied by a recorded full orchestra, and set against an amazing video backdrop. The presentation concludes with a pyrotechnic display of indoor fireworks.

- FOUR COMPLIMENTARY SYMPOSIUM REGISTRATIONS
- OPPORTUNITY TO DISTRIBUTE LITERATURE ON A TABLE AT REGISTRATION
- PLACEMENT OF YOUR COMPANY'S LOGO IN THE AGENDA HANDOUTS AND PROCEEDING
- SIGNAGE OUTSIDE THE PARTICULAR EVENT SPONSORED
- SPONSOR RIBBON ON BADGES

TRADITIONAL STEEL DRUM ISLAND MUSIC (AVAILABLE TO 1 SPONSOR) - $2,500

- ONE COMPLIMENTARY SYMPOSIUM REGISTRATION
- PLACEMENT OF YOUR COMPANY'S LOGO IN THE AGENDA HANDOUTS AND PROCEEDING
- SPONSOR RIBBON ON BADGES

JAZZ TRIO (AVAILABLE TO 1 SPONSOR) - $2,000

- PLACEMENT OF YOUR COMPANY'S LOGO IN THE AGENDA HANDOUTS AND PROCEEDING
- SPONSOR RIBBON ON BADGES

FOR MORE INFORMATION ON SPONSORSHIP OPPORTUNITIES OR TO PURCHASE A SPONSORSHIP, PLEASE CONTACT MICHELLE HARISTON, ASSOCIATE DIRECTOR AT MHARISTON@NDIA.ORG

GENERAL CONFERENCE INFORMATION

ATTENDEE ROSTER:
An attendance roster will be available at the conference registration desk. In order for your name to appear in the roster, you must be registered for this event by May 4, 2009. An updated roster will NOT be printed after the conference.

SPECIAL NEEDS:
NDIA supports the Americans with Disabilities Act of 1990. Attendees with special needs should call or email Michelle Hariston, Associate Director at 703-247-9478 mhariston@ndia.org by May 1, 2009.

US ONLY SESSIONS:

Send citizenship information through JPAS to:
SMO Code: 001745
POC: Janice Crongeyer
Phone: 301-744-4704

If access to JPAS is not available, fax attention to: Janice at 301-744-6406.

NOTE: For confirmation of receipt contact Janice at 301-744-4704 or Robin Potter at 301-744-4667

QUESTIONS?
Please contact Michelle Hariston, Associate Director at (703) 247-9478 or via email at mhariston@ndia.org.

REGISTRATION

NOTE: THERE ARE TWO SEPARATE REGISTRATION PROCESSES. ONE FOR CONFERENCE REGISTRATION AND ONE IF YOU PLAN TO ATTEND US ONLY SESSIONS. ALL CITIZENSHIP INFORMATION SHOULD BE SENT TO JPAS.

ONLINE:

Our preferred method of registration is online. Please go to www.ndia.org/meetings/9560 to register online.

FAX:

Register via fax by completing the Registration Form (PDF) and faxing it to (703) 522-1885. Please do not fax any registrations after May 8, 2009. After this date, please bring your completed registration form with you to the meeting to register on-site or register online.

MAIL:

Registration forms (PDF) may be mailed to: NDIA, Event #9560, 2111 Wilson Blvd., Suite 400, Arlington, VA 22201. Please do not mail any registrations after May 1, 2009. After this date, please bring your completed registration form with you to the meeting to register on-site or register online.

Registrations will not be taken over the phone and payment must be made at the time of registration.

CANCELLATIONS:

Cancellations before 03/20/09 receive a full refund. Cancellations between 03/21/09 - 04/17/09 receive a refund minus a $75 cancellation fee. No refunds for cancellations received after 04/17/09. Cancellations must be made in writing. Substitutions welcome in lieu of cancellations. Please e-mail your cancellations or substitutions to Michelle Hariston, Associate Director at mhariston@ndia.org.

	EARLY (BEFORE 4/7)	REGULAR	ON-SITE (AFTER 4/28)
GOVERNMENT ACADEMIA/ALLIED GOV.	$370	$410	$450
INDUSTRY NDIA MEMBER	$520	$570	$630
INDUSTRY NON-NDIA MEMBER	$570	$630	$695

EVENT #9560 ◆ NDIA REGISTRATION FORM

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION ◆ 2111 WILSON BOULEVARD, SUITE 400 ◆ ARLINGTON, VA 22201-3061
(703) 522-1820 ◆ (703) 522-1885 FAX ◆ WWW.NDIA.ORG

53RD ANNUAL FUZE CONFERENCE ◆ *DISNEY'S CORONADO SPRINGS* RESORT, ORLANDO, FL ◆ MAY 19-21, 2009

SEE JPAS INSTRUCTIONS FOR US ONLY SESSIONS

3 WAYS TO SIGN UP:
1. Online with a credit card at www.ndia.org
2. By fax with a credit card - Fax: (703) 522-1885
3. By mail with a check or credit card

◇ Address Change Needed

NDIA Master ID/Membership #_____ Social Security # _____
(If known - hint: on mailing label above your name) *(Last 4 digits - optional)*

Prefix *(e.g. RADM, COL, Mr., Ms., Dr., etc.)* _____

Name: First _____ MI ____ Last _____

Military Affiliation _____ Nickname _____
(e.g. USMC, USA (Ret.) etc.) *(For meeting badges)*

Title _____

Organization _____

Street Address _____

Address *(Suite, PO Box, Mail Stop, Building, etc.)* _____

City _____ State _____ Zip _____ Country _____

Phone _____ Ext. _____ Fax _____

E-Mail _____

Signature* _____ Date _____

PREFERRED WAY TO RECEIVE INFORMATION

Conference Information	◇ Address above	◇ Alternate (Print address below)	◇ E-mail
Subscriptions	◇ Address above	◇ Alternate (Print address below)	

Alternate Street Address _____

Alternate Address *(Suite, PO Box, Mail Stop, Building, etc.)* _____

City _____ State _____ Zip _____ Country _____

* By your signature above, you consent to receive communications sent by or on behalf of NDIA, its Chapters, Divisions and affiliates (NTSA, AFEI, PSA, WID) through regular mail, e-mail, telephone or fax. NDIA, its Chapters, Divisions and affiliates do not sell data to vendors or other companies.

CONFERENCE REGISTRATION FEES	Early *(Before 4/7)*	Regular	ONSITE *(After 4/28)*
Government/Academia[1]	$370	$410	$450
Industry NDIA Member and affiliates (AFEI, NTSA, PSA, WID)	$520	$570	$630
Industry non-NDIA member[2]	$570	$630	$695

No refunds for cancellations received after 04/27/2009.
Substitutions welcome in lieu of cancellations!

[1] *Includes a free three-year NDIA membership and subscription to* National Defense *magazine for military and government employees.*

◇ No, do not sign me up for the free government membership.

[2] *Registration fees for non-NDIA (or affiliate) members include a one-year non-refundable NDIA membership —$15.00 will be applied for your 12 month subscription to* National Defense *magazine.*

PAYMENT OPTIONS

◇ **Check** (Payable to NDIA - Event #9560) ◇ **Government PO/Training Form #** _____

◇ **VISA** ◇ **MasterCard** ◇ **American Express** ◇ **Diners Club** ◇ **Cash**

If paying by credit card, you may return by fax to (703) 522-1885.

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ ☐☐/☐☐
Credit Card Number Exp. Date

Signature _____ Date _____

BY COMPLETING THE FOLLOWING, YOU HELP US UNDERSTAND WHO IS ATTENDING OUR EVENTS.

PRIMARY OCCUPATIONAL CLASSIFICATION. Check ONE.
- ◇ Defense Business/Industry
- ◇ R&D/Laboratories
- ◇ Army
- ◇ Navy
- ◇ Air Force
- ◇ Marine Corps
- ◇ Coast Guard
- ◇ DOD/MOD Civilian
- ◇ Government Civilian (Non-DOD/MOD)
- ◇ Trade/Professional Assn.
- ◇ Educator/Academia
- ◇ Professional Services
- ◇ Non-Defense Business
- ◇ Other _____

CURRENT JOB/TITLE/POSITION. Check ONE.
- ◇ Senior Executive
- ◇ Executive
- ◇ Manager
- ◇ Engineer/Scientist
- ◇ Professor/Instructor/Librarian
- ◇ Ambassador/Attaché
- ◇ Legislator/Legislative Aide
- ◇ General/Admiral
- ◇ Colonel/Navy Captain
- ◇ Lieutenant Colonel/Commander/ Major/Lieutenant Commander
- ◇ Captain/Lieutenant/Ensign
- ◇ Enlisted Military
- ◇ Other _____

Year of birth _____
(optional)

QUESTIONS, CONTACT:

MICHELLE HARISTON, ASSOCIATE DIRECTOR

PHONE: (703) 247-9478

E-MAIL: mhariston@NDIA.ORG

MAIL REGISTRATION TO:
NDIA - EVENT #9560
2111 WILSON BOULEVARD
SUITE 400
ARLINGTON, VA 22201

FAX TO: (703) 522-1885

National Defense Industrial Association

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
2111 WILSON BOULEVARD, SUITE 400
ARLINGTON, VA 22201-3061
(703) 522-1820
(703) 522-1885 FAX
WWW.NDIA.ORG

53rd Annual Fuze Conference

"Next Generation Fuzing - Maximum Advantage for the Warfighter"



TO REGISTER, VISIT:
WWW.NDIA.ORG/MEETINGS/9560

Fuzing & Firing Systems at Sandia National Laboratories

R. Scott McEntire, Ph.D.
Program Lead
Hard Target Systems
Sandia National Laboratories
rmcenti@sandia.gov
(505) 845-9138

Paul Butler
Manager
Joint DoD/DOE Munitions Program
Sandia National Laboratories
pcbutle@sandia.gov
(505) 844-7874

Presented at: 53rd Annual NDIA Fuze Conference
Lake Buena Vista, Florida

May 20, 2009

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Sandia's Four Mission Areas

53rd Annual Fuze Conference | Lake Buena Vista, FL | May 19-21, 2009

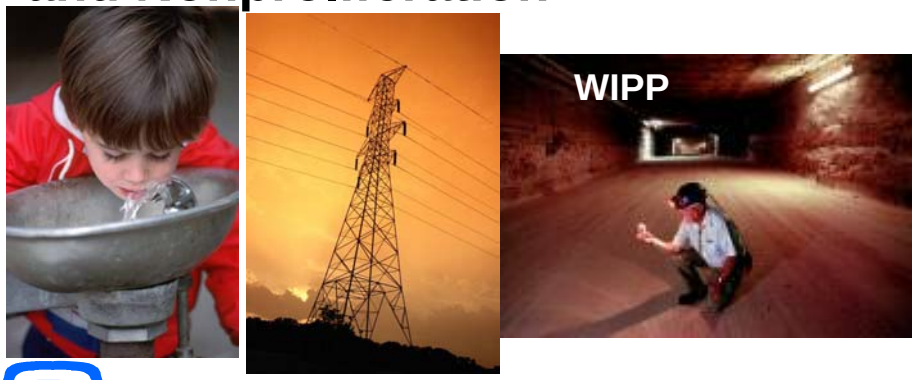
Nuclear Weapons



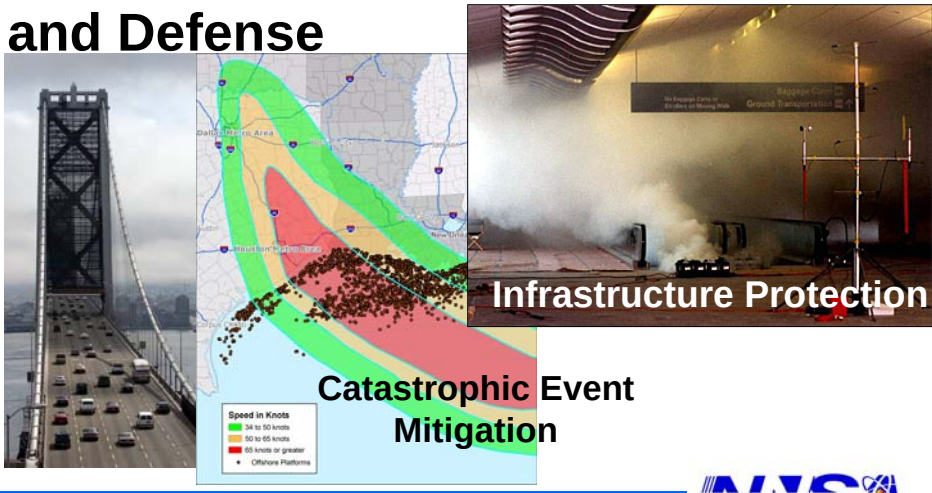
Defense Systems and Assessments



Energy, Resources, and Nonproliferation



Homeland Security and Defense



Sandia National Laboratories

National Nuclear Security Administration

Evolution of Sandia's Advanced Fuzing/Firing Systems Technologies

53rd Annual Fuze Conference Lake Buena Vista, FL May 19-21, 2009

- **Focus on Design and Weaponization**
  - **Mission: design, engineer, integrate, test, and provide production interface, for all non-nuclear components of a nuclear weapon**



B83
Total Parts=6519

- Radar Fuzes
- Impact Fuzes
- Firing Sets
- Shock Absorbers
- Casing
- Detonators
- Capacitors
- Switches
- Switch Tubes
- Rectifiers
- Programmers
- Neutron Generators
- Reservoirs
- Stronglinks
- Batteries
- Timers
- Spin Generators
- Parachutes
- Ejector Systems
- PAL Controllers
- Explosives

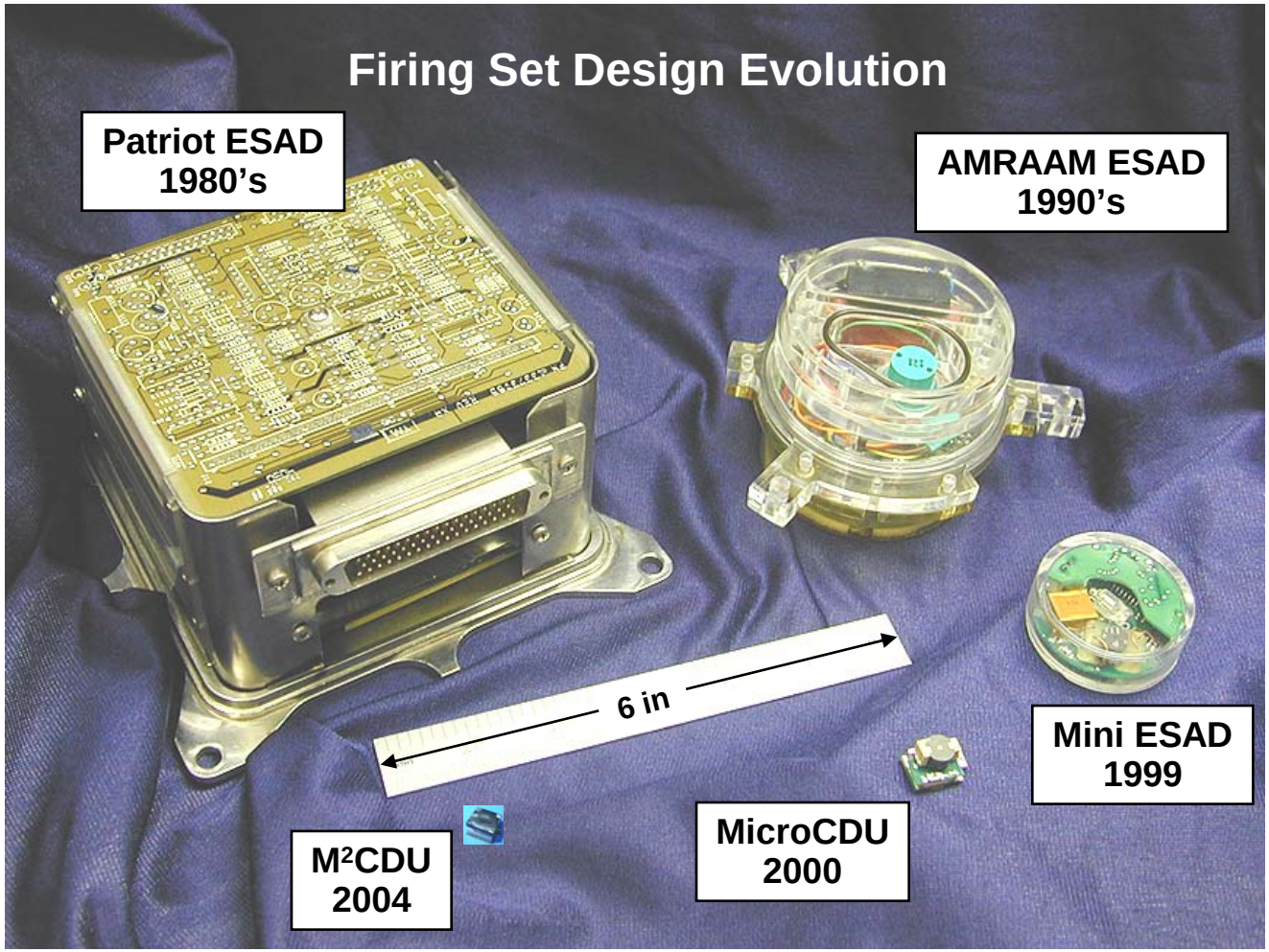


B61-11 Nuclear Earth Penetrator

- **Maintain deep foundation of science and engineering in our technical competencies to position the nation to evaluate and respond to developments in the international environment or to developments in the weapons technology of other nations**

Evolution of Sandia ESAD Fuze Technology

53rd Annual Fuze Conference Lake Buena Vista, FL May 19-21, 2009

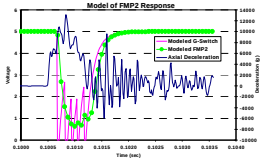


SNL Fuzing/Firing Systems Investment Areas

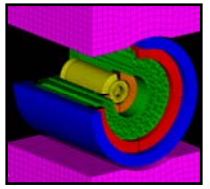
- **Fuze Technology Development**
  - Advance the fuze technology and component development to support the requirements of our new national challenges
  - Explore strategies to survive new environments through miniaturization, integration, and robust packaging



- **Penetration Environment Characterization**
  - Need to better understand the Hard Target penetration environment and fuze component environment



- **Modeling and Simulation**
  - Need the ability to model and predict environments seen by firing systems as penetrating warheads impact hard targets

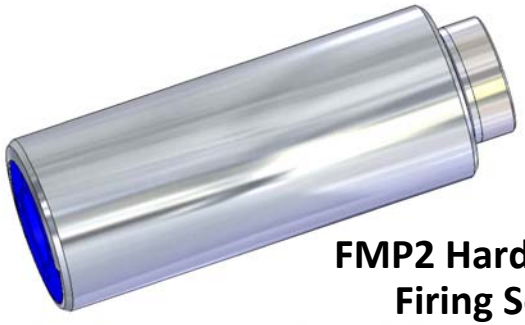


Fuze Technology Development

53rd Annual Fuze Conference Lake Buena Vista, FL May 19-21, 2009

Miniature Electronic In-Line Fuze Modules

Meet safety theme MIL-STD 1316E and MILSTD1901A



FMP2 Hardened Firing Set

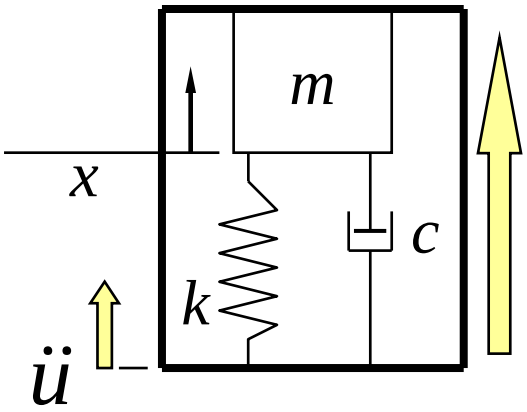
Monolithic MicroCDU (M^2CDU)

Rugged, Miniature, In-Line CDU for ESAD

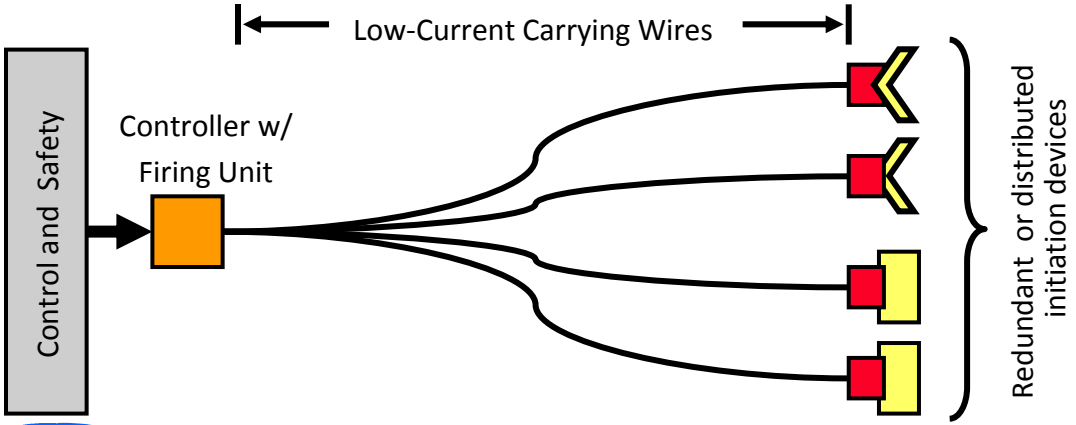


0.36” × 0.40” × 0.20” (T)

Modeling of Sensor Response for Target Detection Improvements

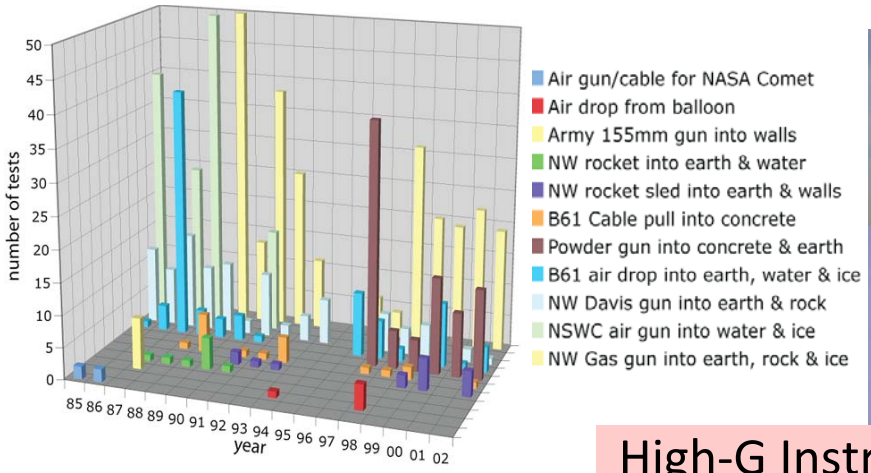


Multipoint Initiation and Selectable Firing



Penetration Environment Characterization

53rd Annual Fuze Conference | Lake Buena Vista, FL | May 19-21, 2009





High-G Instrumentation

MinPen ('97)
3 Axis Recorder





MilliPen ('99)
Single Axis Recorder

3DDR ('09)
3 Axis DTRA
Data Recorder



3AMP ('02)
3 Axis Recorder

Test Article Pre-Test

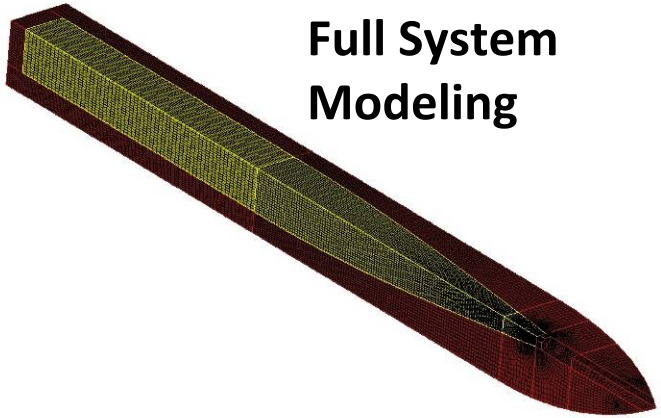




Test Article Post-Test

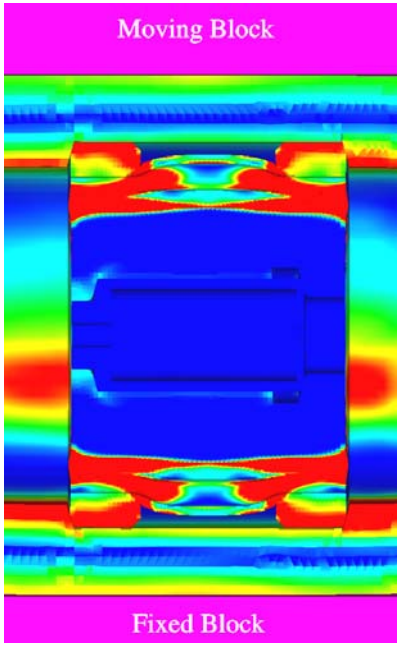


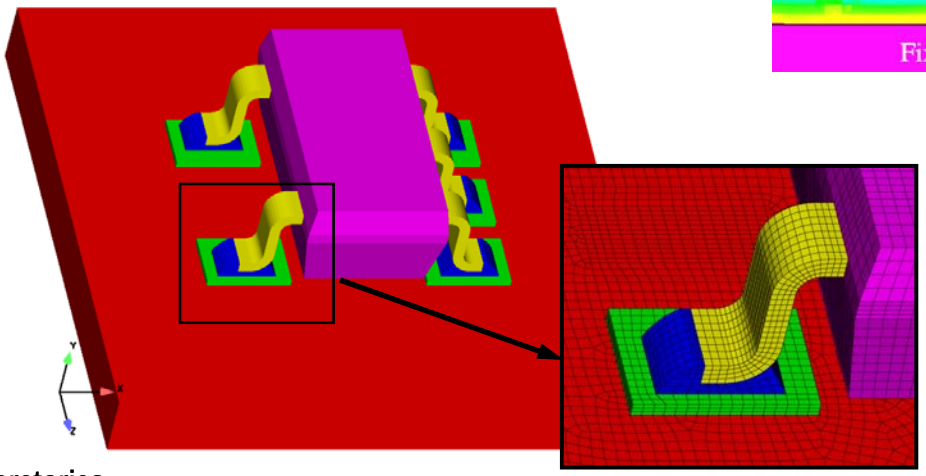
Modeling and Simulation



Full System Modeling

Weapon Component Level Modeling





Modeling of individual circuit components

Fuze Technology Investment Partners

DTRA

Hard Target Fuzing and Instrumentation Research

DOE

Nuclear Weapons Advanced Development

DoD/DOE Joint Munitions Program

Weapons research in Areas of joint interest

Army - AMRDEC

Hardened selectable output warheads

Air Force - AFRL

Collaborative teaming for hard target defeat

Sandia Laboratory Directed Research and Development (LDRD)

High Speed Hard Target Warhead Development

Navy - SP

High speed Hard target defeat

CRADA Partners

DOE Firing Systems for Nuclear Weapons

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Los Alamos NATIONAL LABORATORY EST. 1943

Lawrence Livermore

Develop Main Detonators

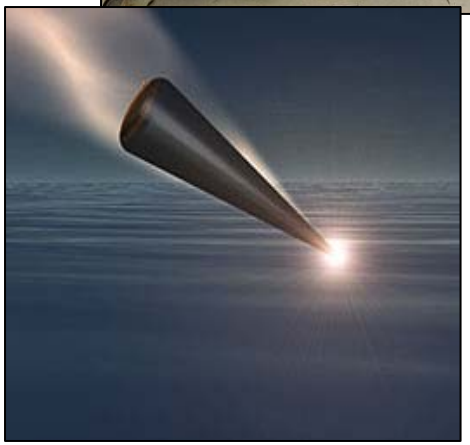
DOE Weapon Firing System

Sandia

Develop Firing Set

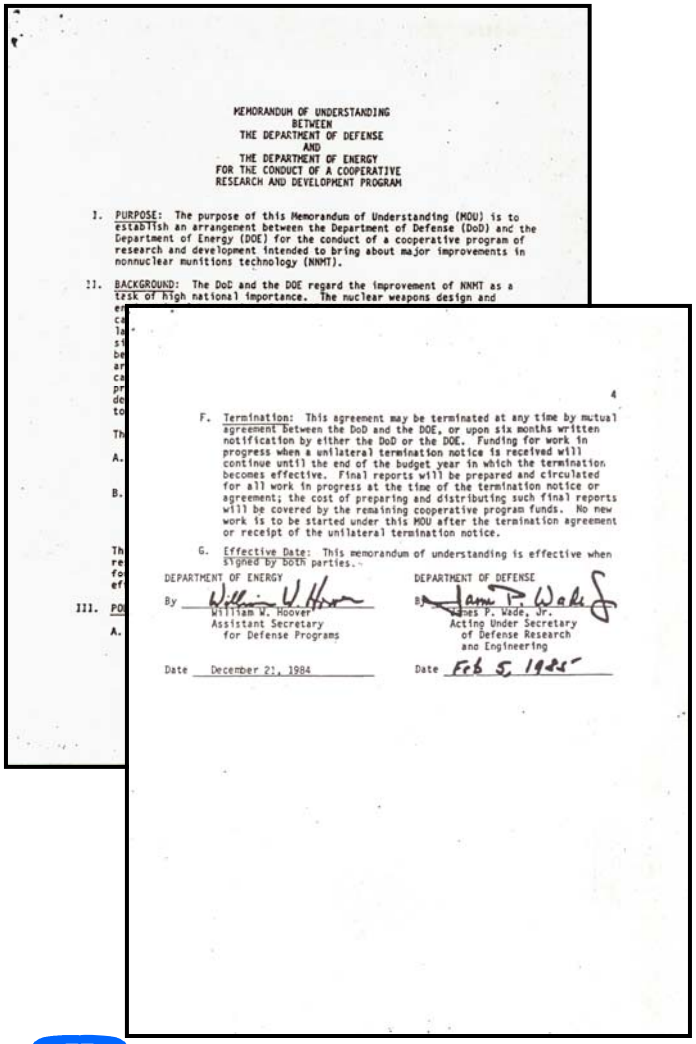
- **Capacitive Discharge Based**
- **Optically Based**





Sandia works with Los Alamos and Lawrence Livermore National Laboratories to develop Firing and Initiation Systems for Nuclear Weapons

Joint DoD/DOE Munitions Program (JMP)
DoD-DOE Memorandum of Understanding



MEMORANDUM OF UNDERSTANDING
BETWEEN
THE DEPARTMENT OF DEFENSE
AND
THE DEPARTMENT OF ENERGY
FOR THE CONDUCT OF A COOPERATIVE
RESEARCH AND DEVELOPMENT PROGRAM

I. PURPOSE: The purpose of this Memorandum of Understanding (MOU) is to establish an arrangement between the Department of Defense (DoD) and the Department of Energy (DOE) for the conduct of a cooperative program of research and development intended to bring about major improvements in nonnuclear munitions technology (NNMT).

II. BACKGROUND: The DoD and the DOE regard the improvement of NNMT as a task of high national importance. The nuclear weapons design and

F. Termination: This agreement may be terminated at any time by mutual agreement between the DoD and the DOE, or upon six months written notification by either the DoD or the DOE. Funding for work in progress when a unilateral termination notice is received will continue until the end of the budget year in which the termination becomes effective. Final reports will be prepared and circulated for all work in progress at the time of the termination notice or agreement; the cost of preparing and distributing such final reports will be covered by the remaining cooperative program funds. No new work is to be started under this MOU after the termination agreement or receipt of the unilateral termination notice.

G. Effective Date: This memorandum of understanding is effective when signed by both parties.

DEPARTMENT OF ENERGY
By William U. Hoover
William W. Hoover
Assistant Secretary
for Defense Programs
Date December 21, 1984

DEPARTMENT OF DEFENSE
By James P. Wade, Jr.
James P. Wade, Jr.
Acting Under Secretary
of Defense Research
and Engineering
Date Feb 5, 1985

- **MOU signed by DoD/DDR&E and DOE/DP in 1985**
- **Goal: explore and develop technologies intended to bring about major improvements in non-nuclear munitions benefitting both Depts.**
- **Jointly funded by DoD and DOE-Labs**
- **Focus and adapt the DOE nuclear weapons technology-base to enable major advances in DoD warfighting capabilities**
- **Support long-term R&D at the 3 DOE NW labs with DoD & DOE oversight**
- **Cooperative, jointly-funded efforts in:**
  - **Initiation, Fuzing, & Sensors**
  - **Energetic Materials**
  - **Computational Mechanics & Material Modeling**
  - **Warhead Technologies**
  - **Munitions Lifecycle**
- **Requires a balance between DoD and DOE priorities**
- **Participation is government only; technologies transitioned thru DOTC and lab mechanisms**

JMP Technology Coordinating Groups (TCGs)

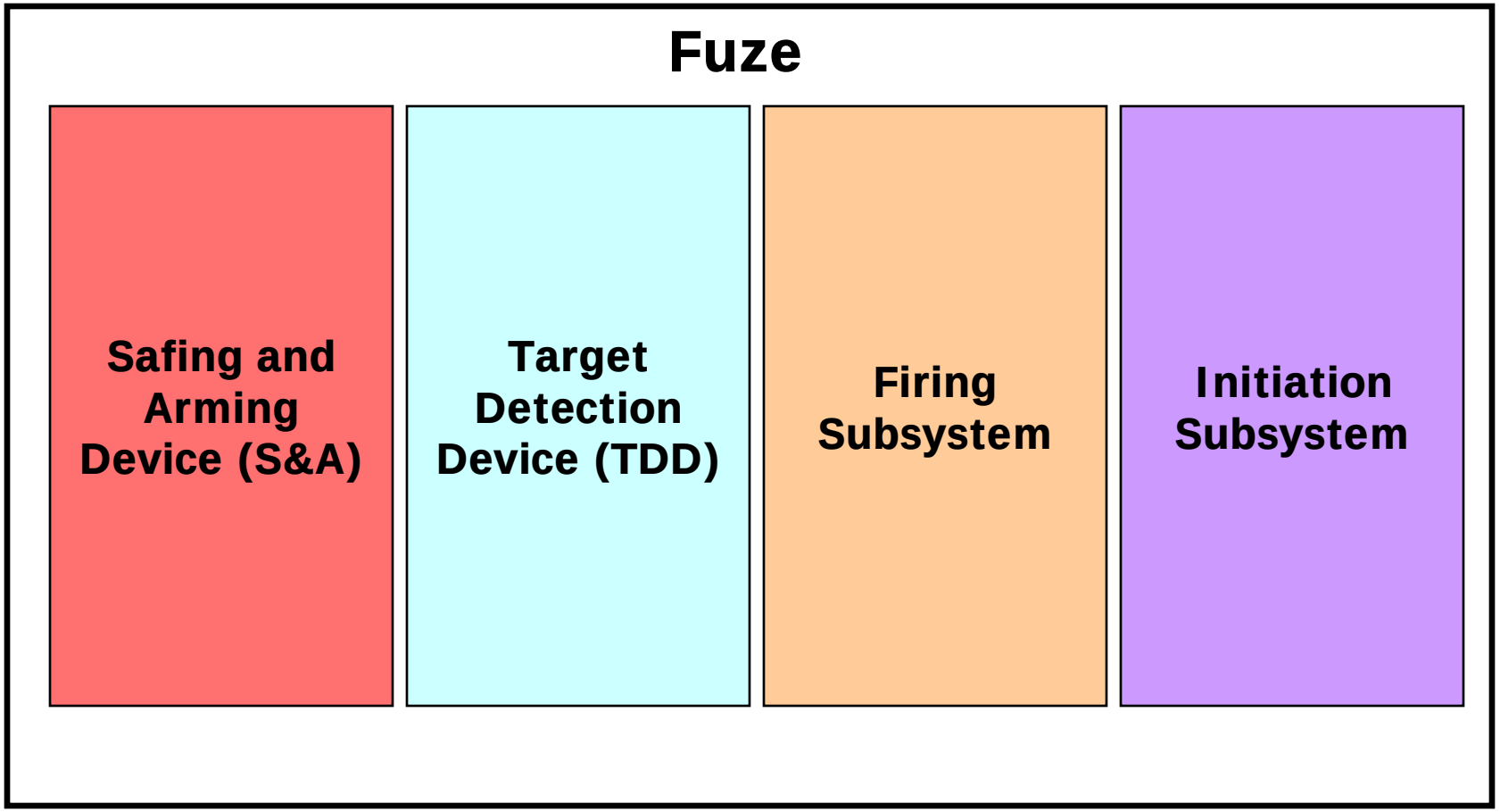
I	Computational Mechanics & Material Modeling
II	Lethality Enhancement & Effectiveness
III	Energetic Materials
IV	Warheads & Integration Technology
IX	Munitions Lifecycle
X	Firing Systems
XI	Penetration Technology
XIII	Sensors
XIV	Predictive Materials Aging & Reliability

Joint Munitions Program & Fuzing/Firing Systems Projects

- Los Alamos, Lawrence Livermore, and Sandia National Labs have active R&D projects in this area
- Technologies such as Exploding Foil Initiators, Monolithic Micro Capacitive Discharge Units (M^2CDU), and Low-Temperature Co-fired Ceramic (LTCC) Transformers have been developed and transitioned
- Once technologies are sufficiently mature, they are offered for transition to industry through the Defense Ordnance Technology Consortium (DOTC) (http://www.nwec-dotc.org/) and laboratory mechanisms
- DOTC development programs are opportunities to reduce new technology risk and achieve production readiness

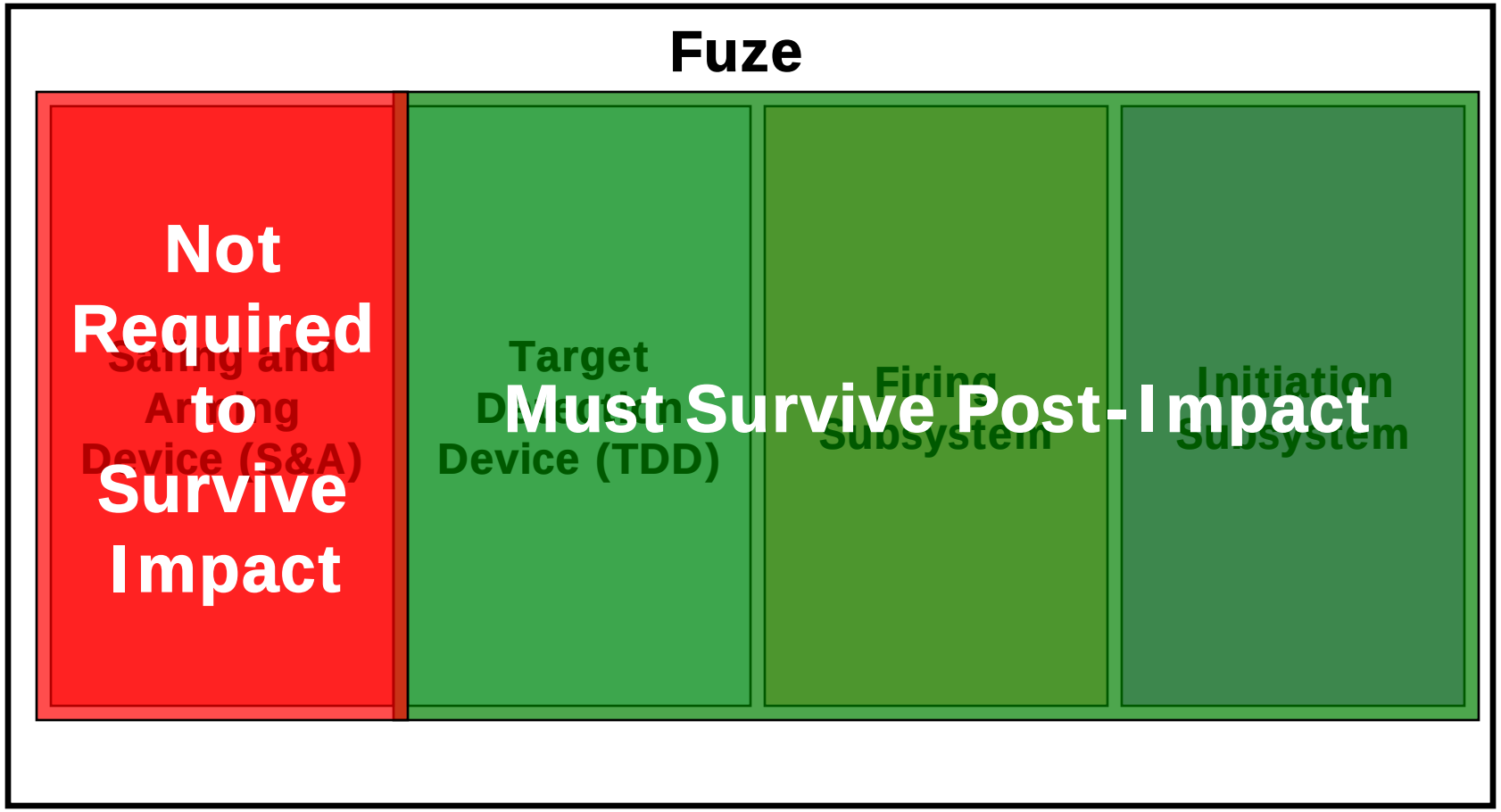
What is a Fuze?

Simplified Fuzing Functions

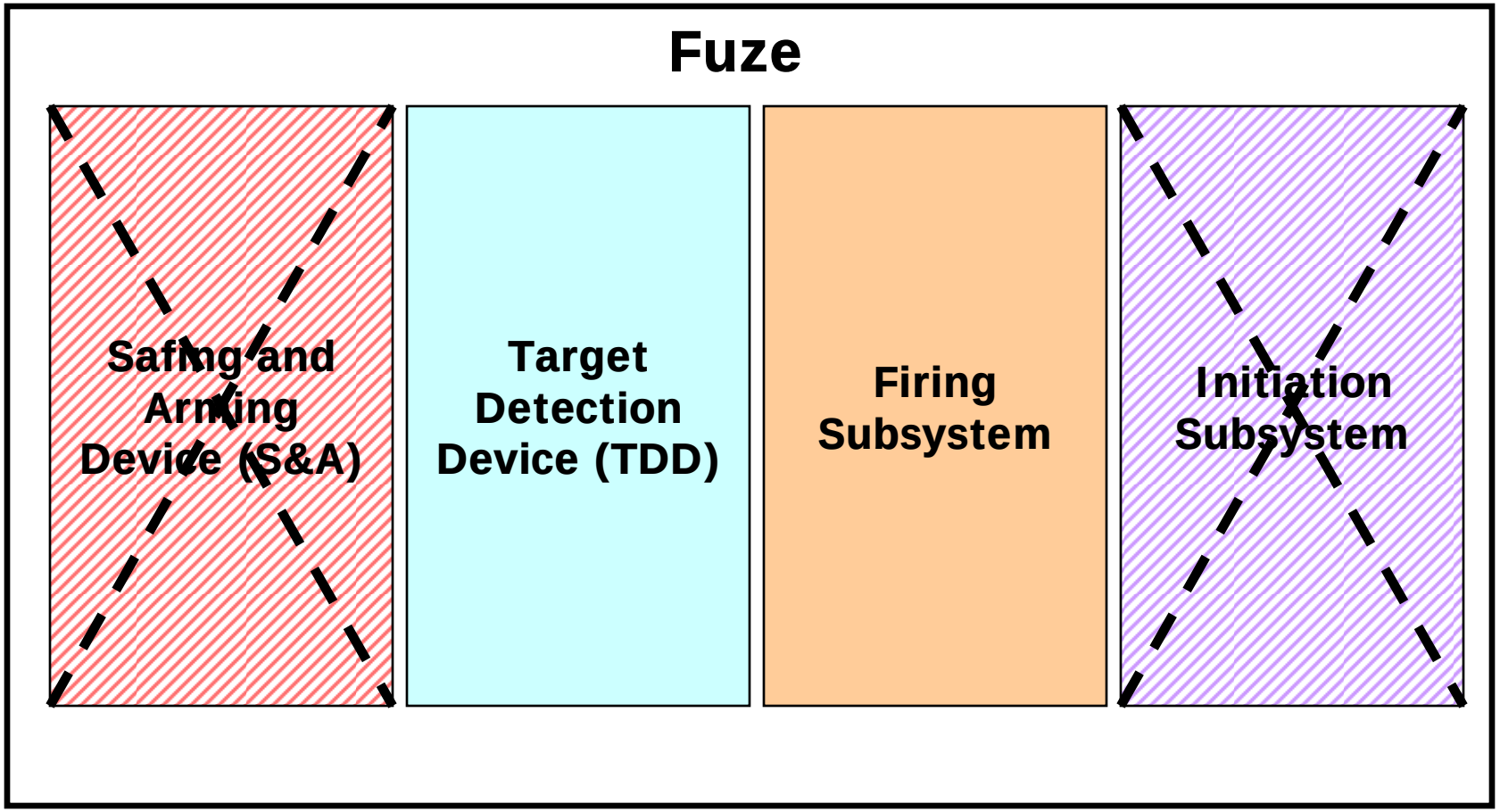


What is a Fuze?

Simplified Fuzing Functions (As applied to Post Impact Survival Fuzing)



DTRA Funded Fuze Diagnostic Recorder (FDR) Focus Areas

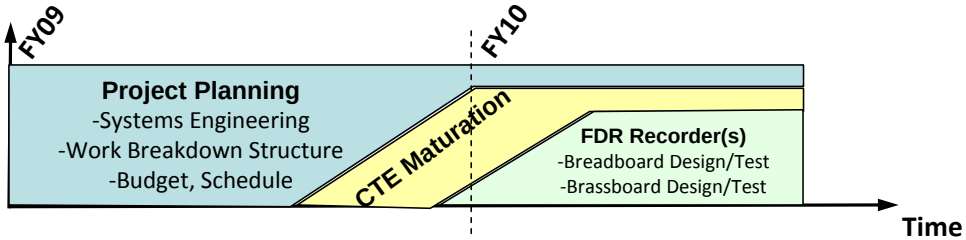


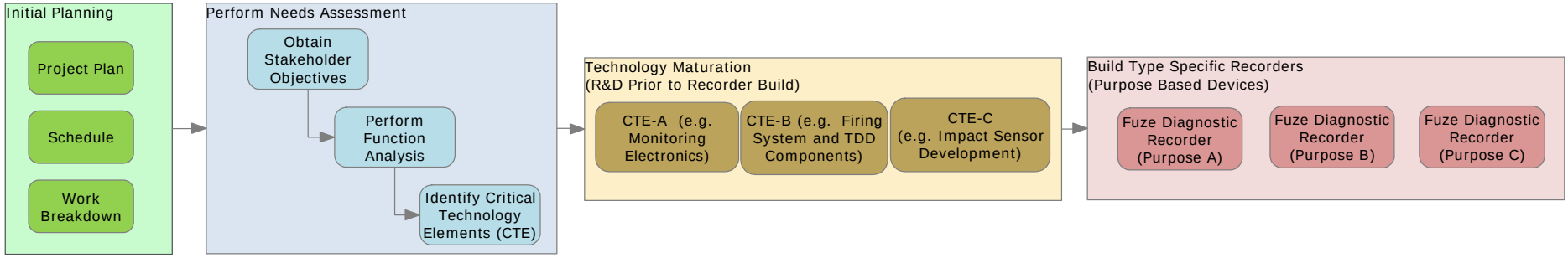
DTRA Fuze and Instrumentation Technology
Fuze Diagnostic Recorder (FDR) Program

53rd Annual Fuze Conference Lake Buena Vista, FL May 19-21, 2009

- **PROJECT GOAL:**
  - Improve electronic hard target fuzes by monitoring and recording post-impact critical functions in harsh impact environments.

- **RESEARCH OBJECTIVES:**
  1. Improve understanding of weaknesses and failures in electronic firing systems exposed to hard target environments.
  2. Develop methodologies for data collection of post-impact critical components to enable objective #1.
  3. Improve impact detection and target sensing by monitoring a suite of inertial impact sensors.





End of Presentation

Questions?

Paul Butler
Manager
Joint DoD/DOE Munitions Program
Sandia National Laboratories
pcbutle@sandia.gov
(505) 844-7874

R. Scott McEntire, Ph.D.
Program Lead
Hard Target Systems
Sandia National Laboratories
rmcenti@sandia.gov
(505) 845-9138

Hae-Jung Murphy
Manager
Hard Target Systems
Sandia National Laboratories
hlmurph@sandia.gov
(505) 845-7501

NDIA's 53nd Annual Fuze Conference

US NAVY OVERVIEW

Rev 7.4 – 20 May 09



Randall Cope

Associate Dept. Head for Energetics

NAWCWD, China Lake CA

NAVAIR

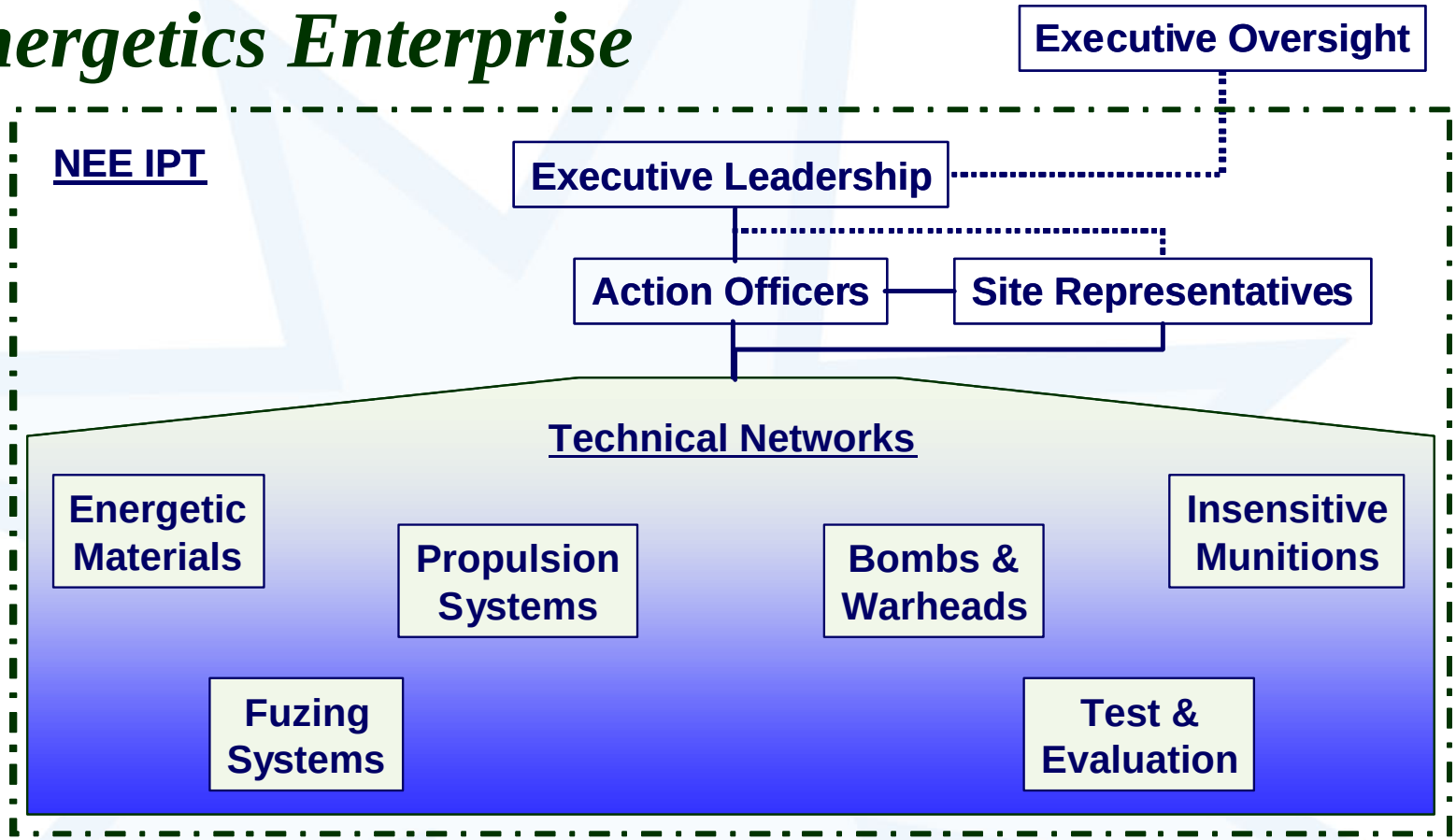
NAVSEA
WARFARE CENTERS

Approved for public release; Distribution is unlimited.

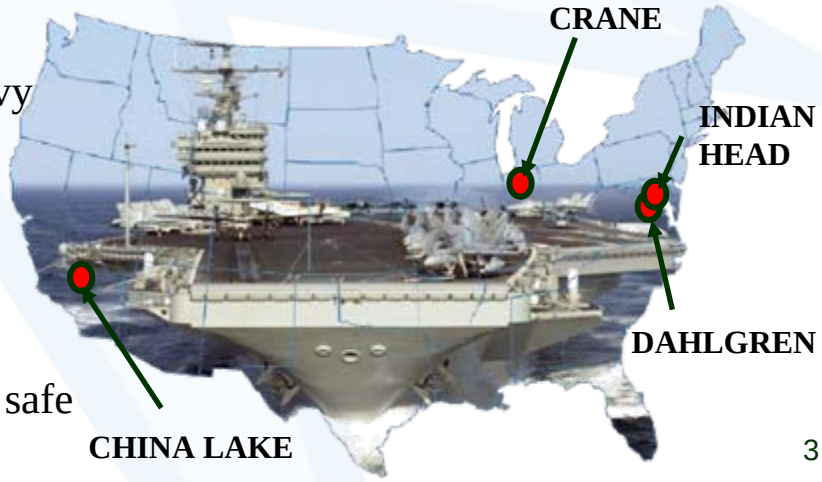
Outline

- **Naval Energetics Enterprise Overview**
- **Fuze Safety Review Process & Panel**
- **Capabilities**
- **Future of Fuzing**
- **Summary**

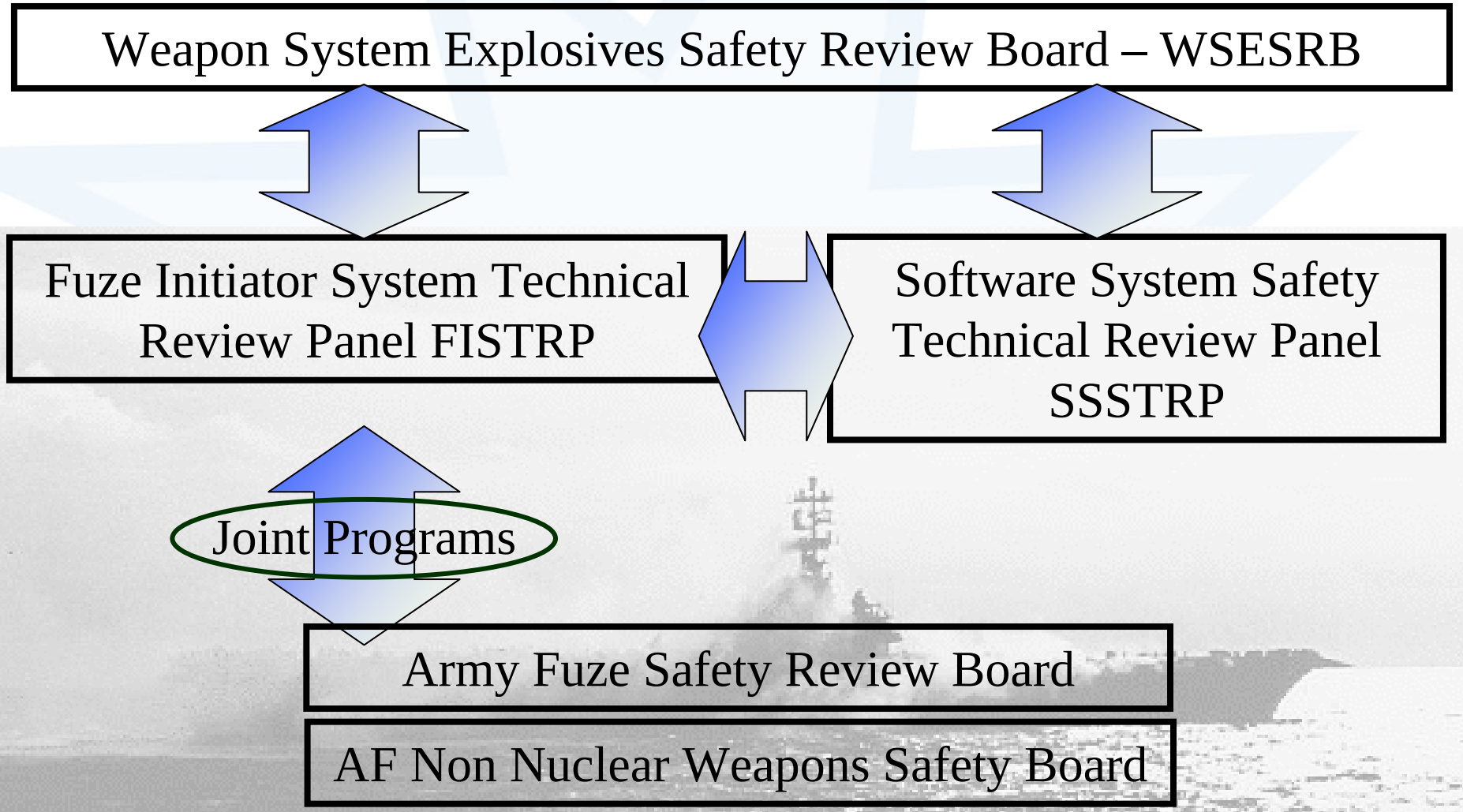
Navy Energetics Enterprise



- Provide stewardship of unique Navy capabilities to ensure current and future Navy warfighting requirements are attainable and supportable
- Speak with a single Navy voice
- Work together to improve efficiency and rationalize resources to provide responsive, safe and affordable ordnance solutions



Navy Fuze Safety Review Process



Fuze and Initiation Systems Technical Review Panel (FISTRP)

Panel Chair – Jack Waller

Panel Members –

Raymond Ash
Randy Cope
John Hendershot
John Kandell
Scott Pomeroy
Melissa Milani
Ralph Balestieri
Micheal Demmick
John Hughes
David Libbon
Gabriel Soto
Tinya Coles-Cieply
Bradley Hanna
George Hennings
Eugene Marquis
Brian Will

Current Topics of Interest/Challenge

Charge-Based Memory – Reconfigurable Logic
Environmental Sensing for Smart Weapons

MIL-STD-1316 STANAG 4187
MIL-STD-1901 STANAG 4368
MIL-STD-1911 STANAG 4497

Fuze & Initiation Technology Development Capabilities at Indian Head

MEMS Clean Room

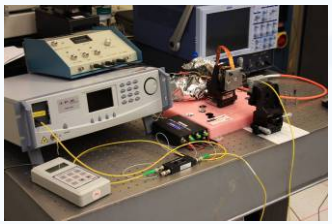
Navy Unique Facility for Integrating Micro System, Electronics , Initiation and Explosives Component Technologies

- Class 10,000 Clean Room
- Explosive and Micro Systems Assembly
- Component Packaging
- Device Characterization
- Fiber Optic Integration
- Electrical and Mechanical Testing
- Photonic Doppler Velocimetry (PDV)
- Firing Circuits & Diagnostic Suite



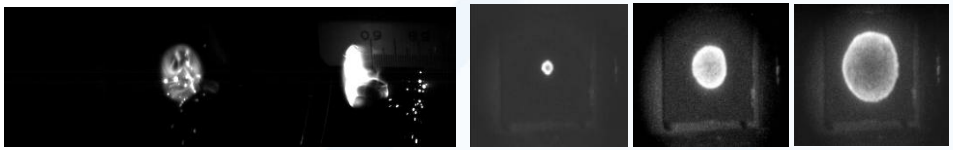
Parallel Seam Welder

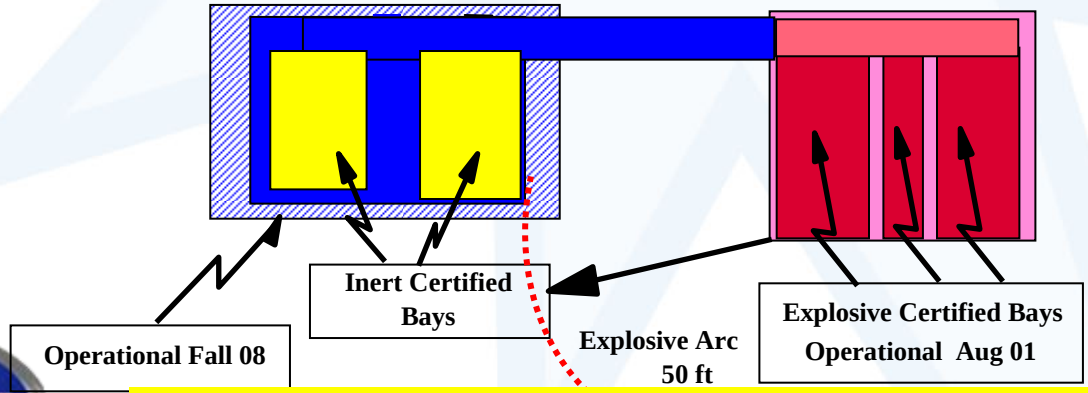




PVD









10 Gm Explosive Test Chamber

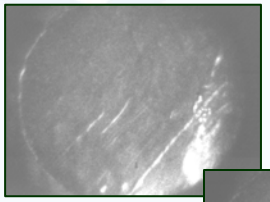
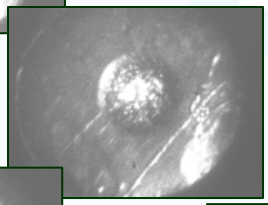
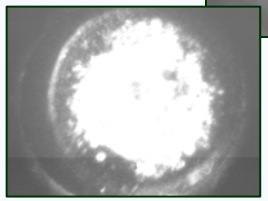
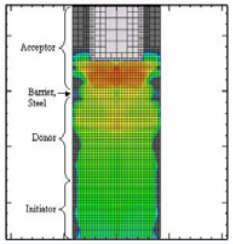
State of the Art Facility

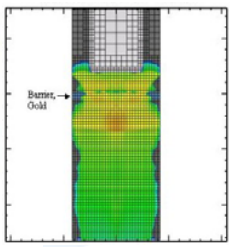
Fuze & Initiation Technology Development Capabilities at China Lake

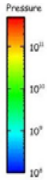
Cutting Edge Design Capabilities
- MEMS Design
- ASIC Design
- CAD/CAM

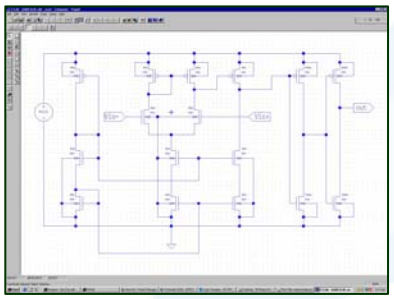
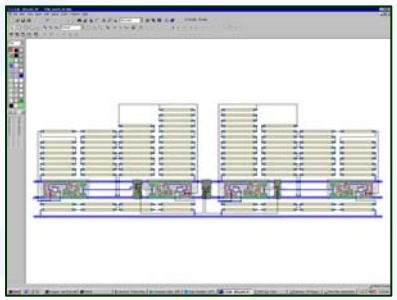
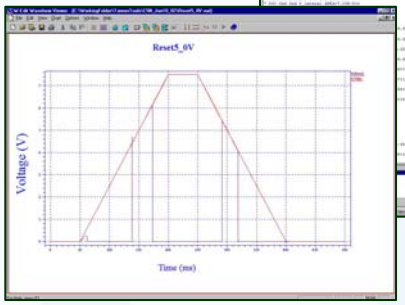
Test capabilities
- Small and Large Scale Test Facilities
- Fuze Laboratory
- P749

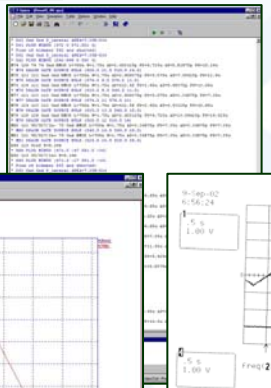
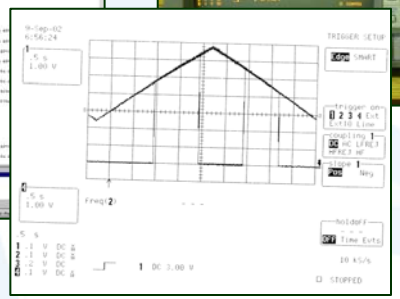
EFI detonators & Initiators

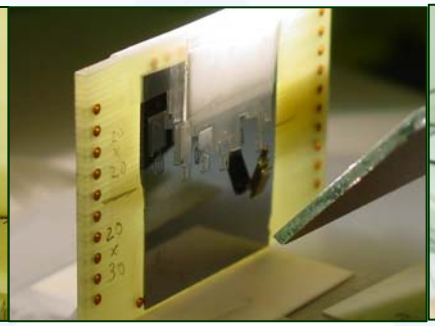











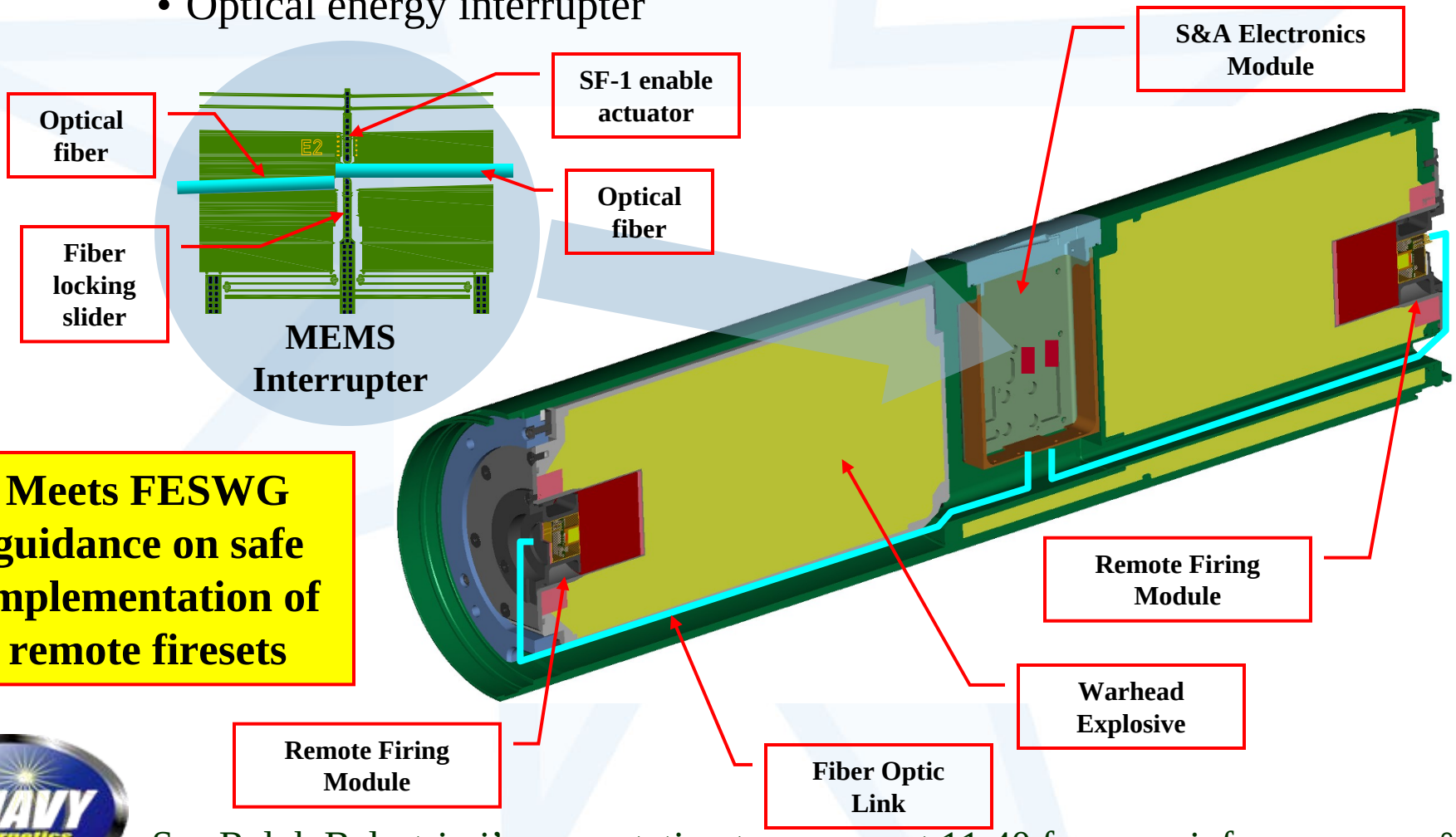

Next Generation Fuze Technologies

- Miniature Munitions
  - Low cost, small size
    - Common Architecture S&As
      - Leveraging of existing designs
      - Modular architectures
    - MEMS technology for low cost fuzes
    - Miniature ESAD technology
    - RF Proximity sensor for small high speed targets
      - Flexible proximity sensing through DSP
      - Use broadband/Spread Spectrum technology
    - Thin film thermal battery
- Niche applications
  - Performance more important than cost
    - Higher end guided applications, multi-mode weapons
    - Survival of harsh environments
    - Very high reliability

Optically Linked Remote Firesets

Components

- Remote miniature firesets with high voltage EFIs
- Optical charging energy
- Optical energy interrupter



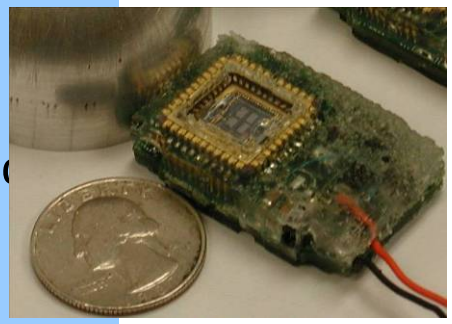
Meets FESWG guidance on safe implementation of remote firesets

See Ralph Balestrieri's presentation tomorrow at 11:40 for more info

MEMS S&A Technology

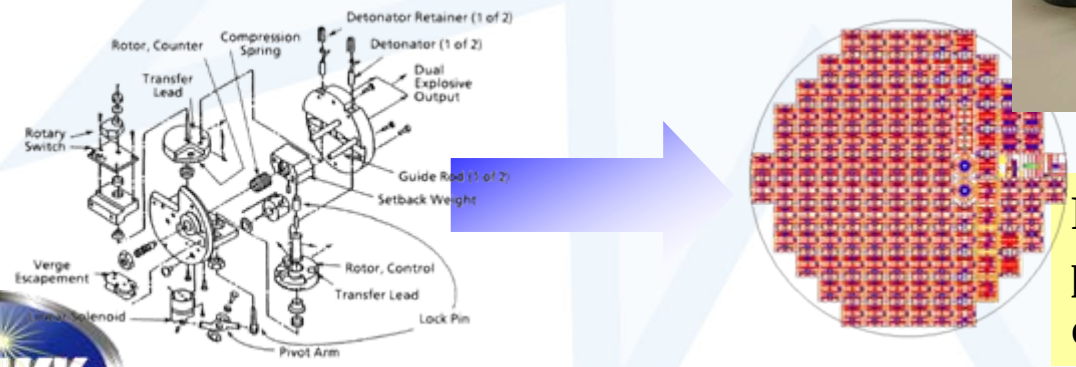
Revolutionary Research . . . Relevant Results

- Capitalizes on commercially available IC large scale batch fabrication techniques
- In-Situ (formed in place) micro detonator technology … no energetic waste material … no processing equipment exposed energetics
- Reduces fuze cost and size
- Successfully demonstrated in 40,000 G setback environment



MEMS in-situ detonator based S&A device technology currently TRL 5



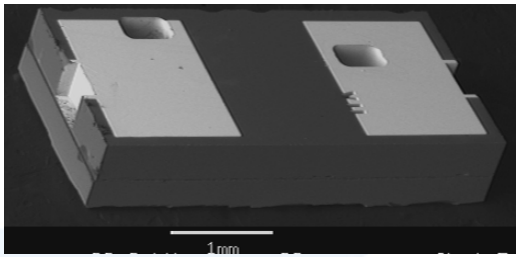


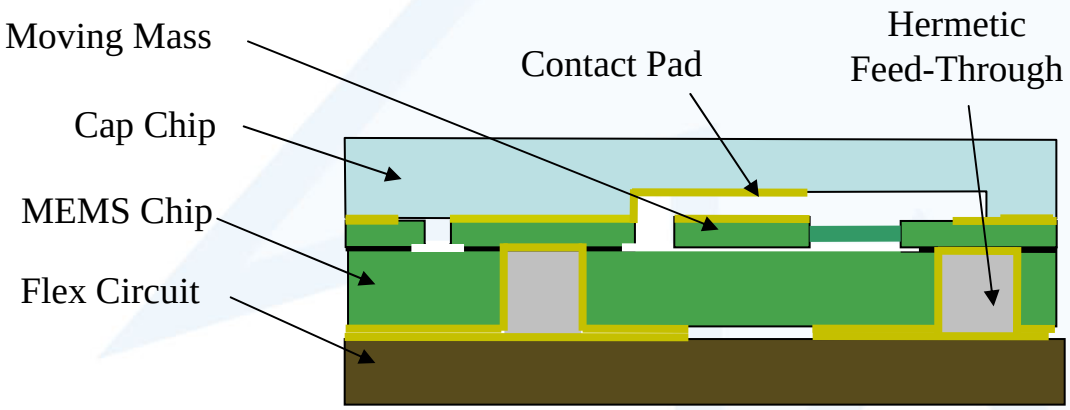
From tens of mechanical parts per fuze to 100's of fuze chips per single wafer

See Dr. Dan Jean's presentation tomorrow at 9:00 for more info

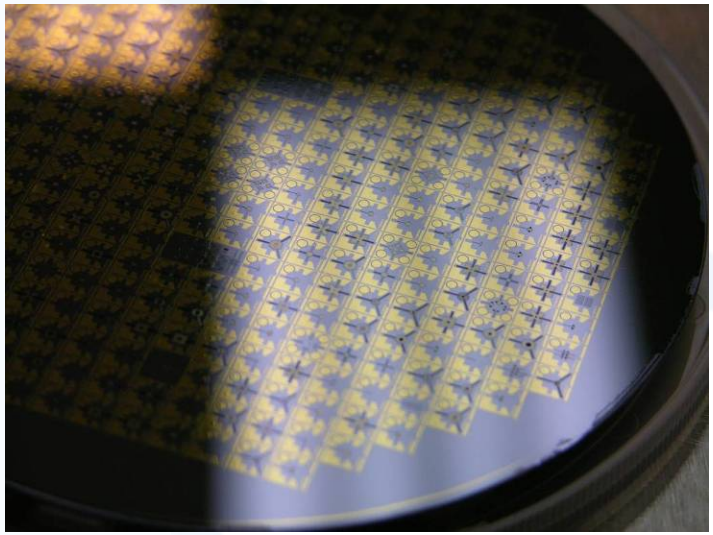
Contact Switch for Point Detonation

- MEMS Based Impact Sensor
  - Low profile: less than 900 µm tall
  - Withstand 50 kG launch, detect 150 G
  - 2 rounds of design and fabrication completed in 2007 (60 sensors delivered)
  - 1 round of design and fab in 2008, (15 sensors delivered)
  - Hermetically sealed, size is 2 x 4 x 0.8 mm





Surface Mount Switch Schematic

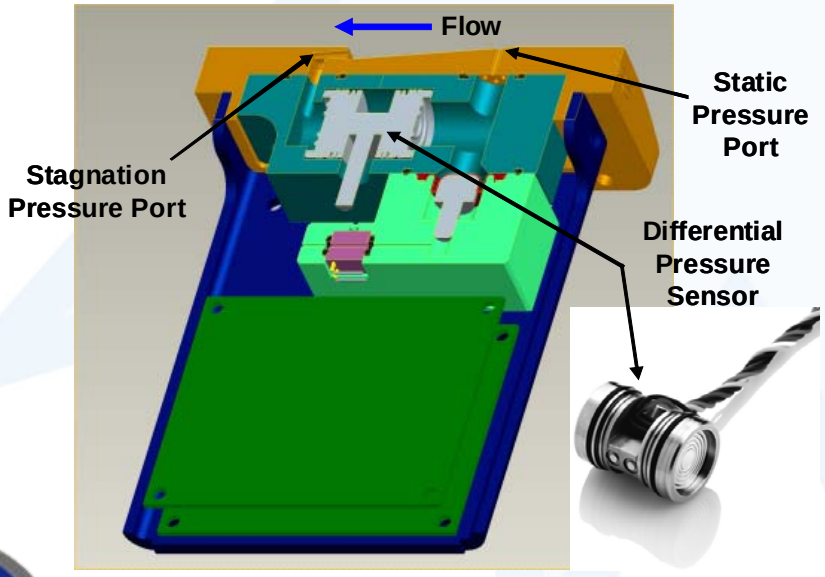


4” Wafer of Contact Switches

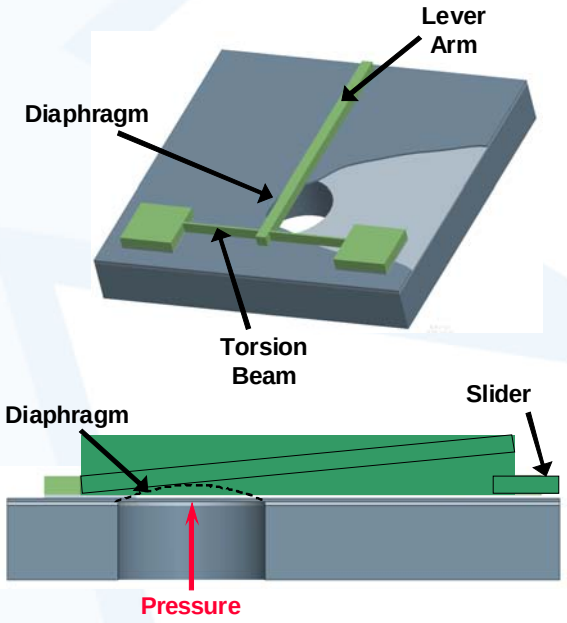
See Eddie Chen’s presentation tomorrow at 2:00 for more info

MEMS Underwater Sensors

- **Miniature sensors developed for torpedo applications**
- **Differential pressure flow sensor**
  - **Incorporates a silicon MEMS piezoresistive pressure sensor**
  - **Difference between the total pressure and the static port correlates to the flow speed for a given fluid**
- **Hydrostat**
  - **Microfabricated diaphragm that deflects with pressure**



Differential Pressure Flow Sensor



MEMS Hydrostat

Miniature Munitions and Low Cost Applications

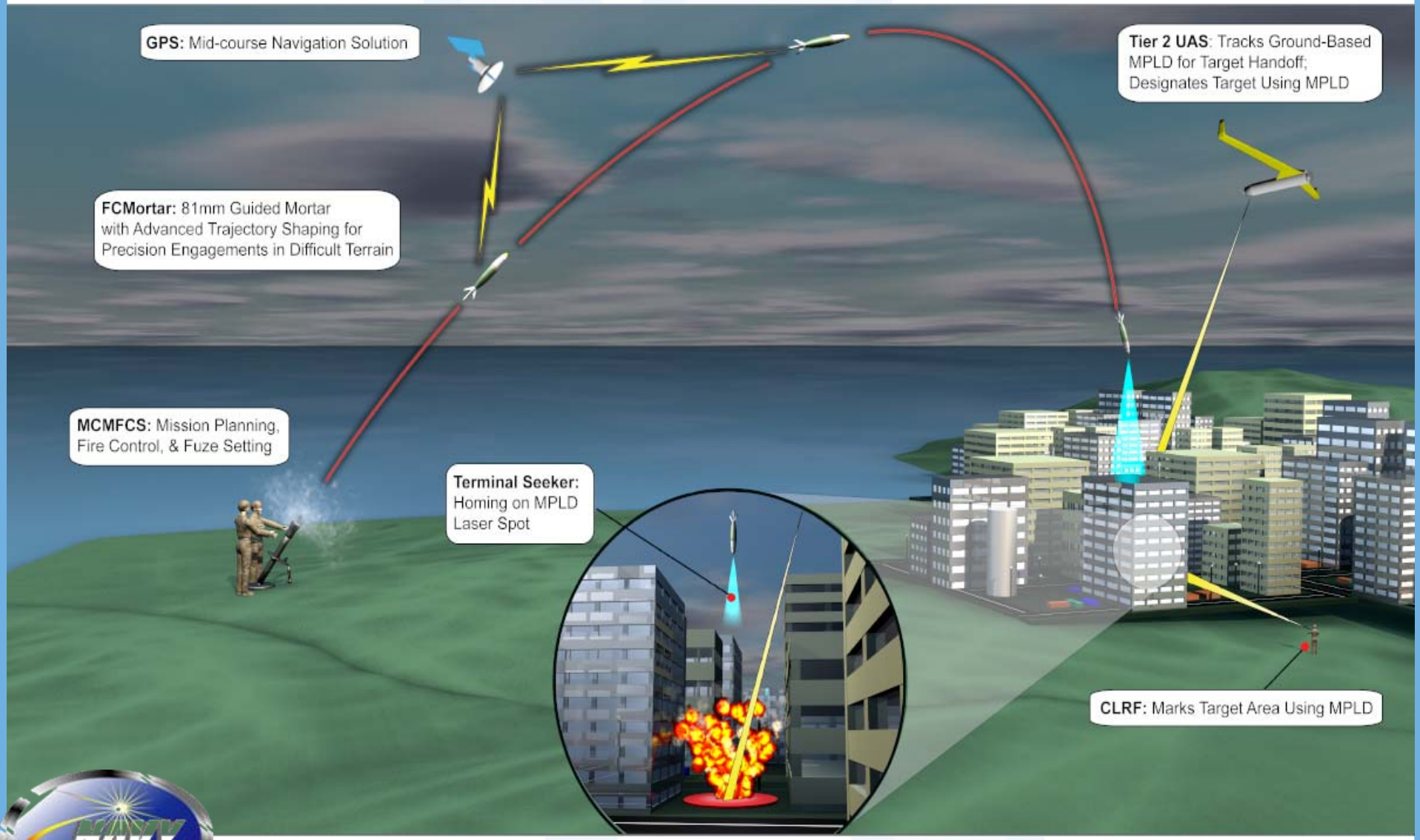
- **Developing low-cost solutions for miniature applications**
  - Utilizing COTS components
- **Component Evaluation**
  - High-Voltage Ceramic Capacitors
    - Size, Cost, Energy Output, Temp and Voltage Coefficients, and durability
  - Transformers
    - Charge time w/ available input power
      - Fast charge time applications
      - Low power applications
    - Size and Cost
  - High-Voltage Switches
    - Planar, MCT, Gas Breakdown Tubes, and Sprytron
    - Size, Cost, and Efficiency
- **Full-custom ASIC design**





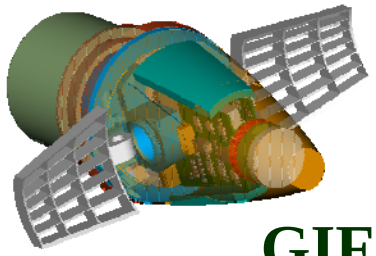
Precision Urban Mortar Attack

PUMA



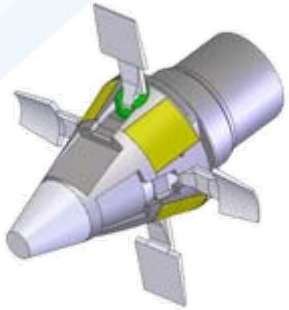
See Luke Steelman's presentation at 1:20 this afternoon for more info

Long Range Gunnery Technology

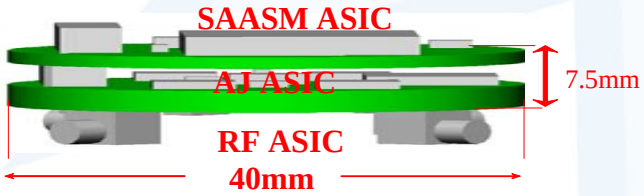


GIF

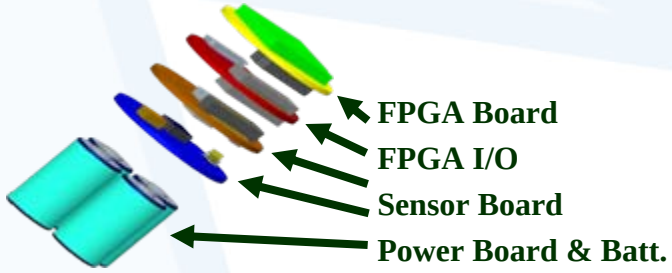
- **GIF - Guidance Integrated Fuze Demonstration**
  - TRL 5-6, Close-Loop Guidance – May 2008
- **VIPER Fuze Design**
  - Preliminary Design and Basic Research Completed
- **ETF - Electronic Test Fuze**
  - UUT Control & Power, Sensors, Telemetry Data
- **GPS P(Y) SAASM Receiver**
  - Available Mar. 2010, (C/A version available now)



VIPER



SAASM GPS Receiver



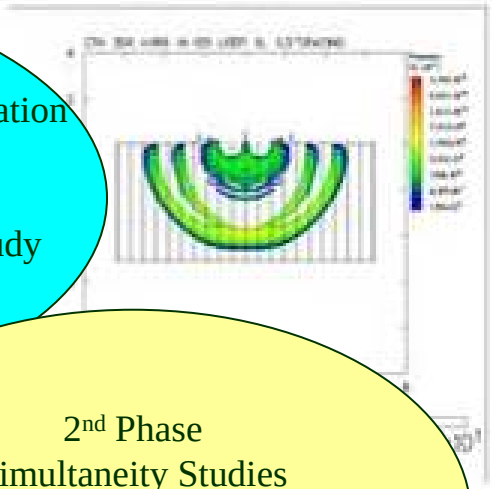
ETF

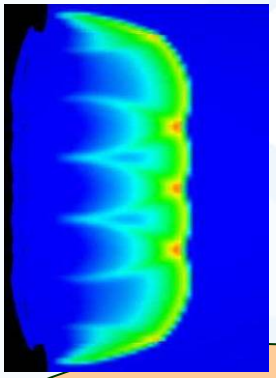
See Wayne Worrell's presentation at 2:20 this afternoon for more info

Extremely Insensitive Detonating Substance (EIDS) Initiation System

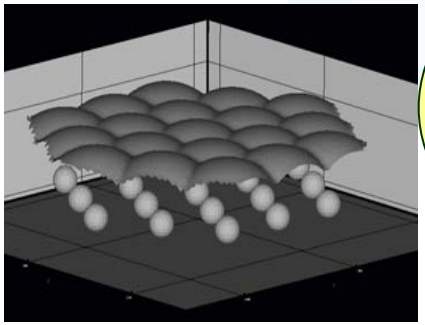
- An Initiation System that emulates large diameter boosters for use in initiating EIDS materials
- OSD funded through Joint Insensitive Munition Technology Program
- Joint Navy (NEE) led effort with Air Force, Army, & Los Alamos participation
- Improved IM performance through elimination of large, relatively sensitive booster
- System requires simultaneous initiation of multiple detonation points

1st Phase (Current Phase)
Modeling to develop theoretical configuration
Development of fireset electronics
Initiation System Configuration
Initiation Growth & Corner Turning Study
EFI PIC Development
Feasibility Study









2nd Phase
Simultaneity Studies
Detonation Merging & Wave Shaping
Initiation Growth Modeling & Testing
Fireset & Initiation System Optimization

3rd Phase
Large Scale EIDS Material Testing
Large Scale Critical Diameter Testing
MIL-STD-2105 Testing (Limited)

See Dave Olson's presentation tomorrow at 11:00 for more info

Summary

Today's Navy

- **NEE - Leveraging the abilities of multiple installations**
- **FISTRP / FESWG / Joint Reviews - Safety conscious**
- **Cradle to grave support of the warfighter**
  - **Concept**
  - **Advanced Development**
  - **Research and Development**
  - **In-Service Support**
  - **Quality Assurance**

US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

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ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER PICATINNY ARSENAL, NJ

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

ARDEC Overview – 53rd Annual NDIA Fuze Conference
20 May 2009
COL Scott Flynn
Deputy Director (A), ARDEC

ARDEC Overview - Agenda

- ARDEC Overview
- Army Fuze Safety Review Board Support
- ARDEC Fuzing Technology Initiatives
- ARDEC Fuzing In-House Capabilities
- Fuze Technology Integration
- OIF Experiences
- Summary

Research



Development



Production



Field Support



Demilitarization



Vision:

Innovative Armaments Solutions for Today and Tomorrow

Mission:

To develop and maintain a world-class workforce to execute and manage integrated life-cycle engineering processes required for the research, development, production, field support and demilitarization of munitions, weapons, fire control and associated items

Advanced Weapons – line of sight/beyond line of sight fire; non line of sight fire; scalable effects; non-lethal; directed energy; autonomous weapons

Ammunition – small, medium, large caliber; propellants; explosives; pyrotechnics; warheads; insensitive munitions; logistics; packaging; fuzes; environmental technologies and explosive ordnance disposal

Fire Control – battlefield digitization; embedded system software; aero ballistics and telemetry

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ARDEC Provides the Technology for Over 90% of the Army's Lethality; Significant support to other Services Lethality

ARDEC Video

Team Picatinny

Assigned/Direct Support ——
Coordination .....

ASA, AL&T

AMC

IMA

JM&L LCMC

TACOM LCMC

Garrison Commander

RDECOM

PEO Ammo/CG

ARDEC

- PM CAS
- PM CCS
- PM JS
- PM MAS

US SOCOM

- Population 4,237
- 6,493 Acres
- 804 Buildings
- 64 Laboratories

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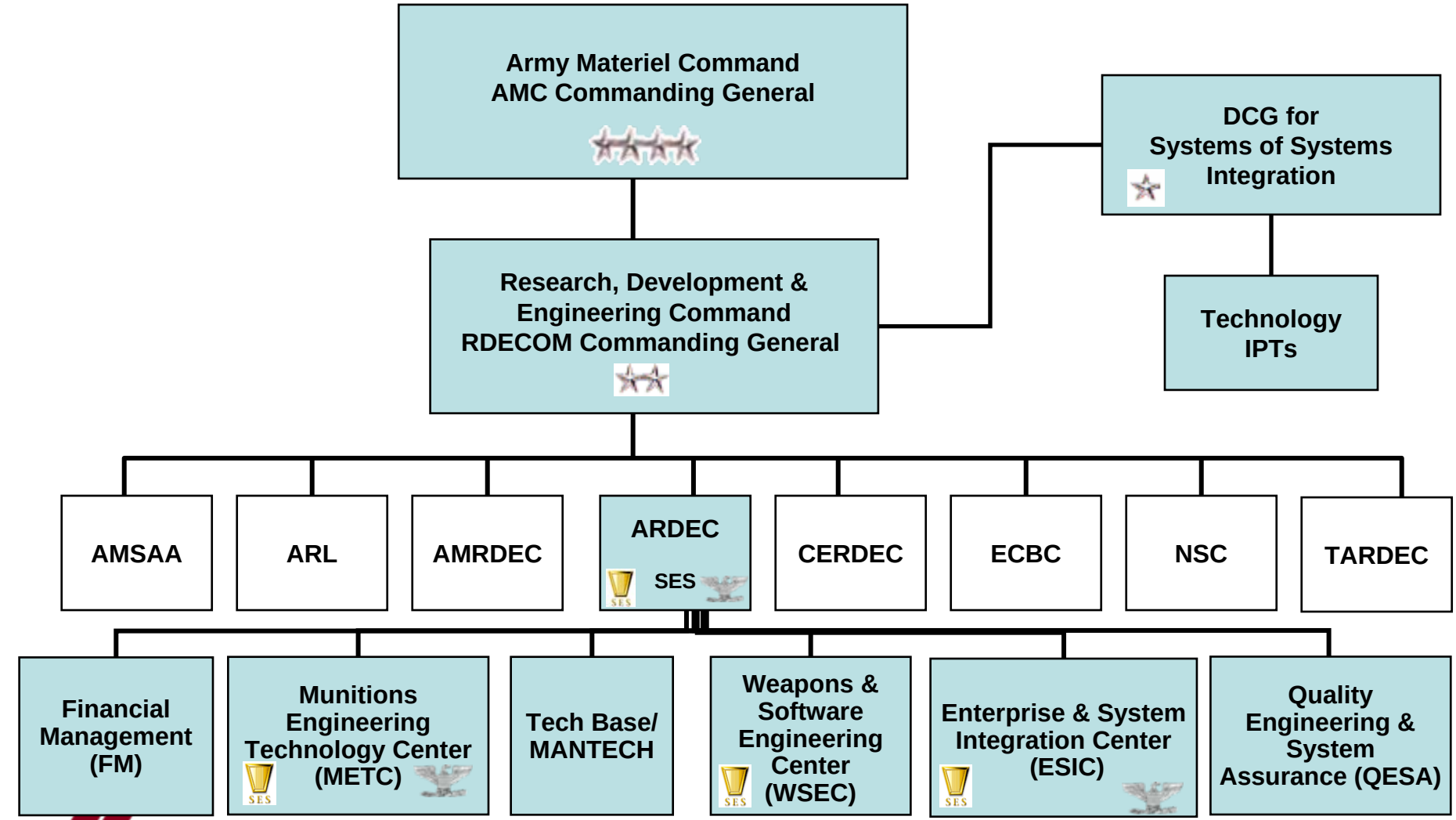
Other Tenants

- PEO Soldier
  - PM Soldier Weapons
- PM FCS BCT
  - PM Lethality
- PEO GCS
  - PM JLW155
- DCMA
  - DCMA NE
- CPAC
- Navy

NAVSEA WARFARE CENTERS DAHLGREN

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

ARDEC Organization - Chain of Command



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Armament Research, Development & Engineering Center - Organization

US ARMY RDECOM

Tech Base/MANTECH
A. Aprea (A)
X5015

Warhead Technologies
R. Fong
X2516

Director/Deputy Director
Dr. Joseph A. Lannon/COL Russell Hrdy
6000/7000

Special Staff
Inspector General: J. Szatkiewicz, X6426
IRAC: D. Murawski, X6360
Legal: D. Scott, X3410
Small Business: E. Bankit, X3068
Administrative Operations: P. Rowland, X7243
Operations, Intel, & Security: M. Felix, x8552

Weapons & Software Engineering Center
D. Castellano
X6444

- **Fire Control Systems & Technology Directorate**
  Victor Galgano (A)
  X6021
- **Weapon Systems & Technology Directorate**
  Mark Ford (A)
  x3425
- **Benét Laboratories**
  Lee Bennett (A)
  DSN 374-4736

Quality Engineering & System Assurance Directorate
D. Carra
X3918/4738

Munitions Engineering Technology Ctr.
LTC Bosworth/J. Hedderich III
X6196/x6173

- **Munitions Systems & Technology Directorate**
  Ernest Logsdon
  X8166
- **Fuze & Precision Armaments Technology Directorate**
  William Smith
  X7258
- **Explosive Ordnance Disposal Technology Directorate**
  John Bostonian
  X7643
- **Energetics, Warheads & Environmental Technology Directorate**
  Ross Benjamin
  X4287

Financial Management Office
M. Manser
X8625

- **Log Res & Eng Directorate**
  Robert Rossi
  X2168
- **Joint Service Small Arms Program Office**
  Joel Goldman
  X6060
- **Army Fuze Management Office**
  Chris Janow
  X5438
- **Project Integration Office**
  Vince Matrisciano (A)
  X2675
- **Systems Engineering Dir**
  Jeff Dyer
  X4707

Enterprise & System Integration Ctr.
COL S. Flynn/K. Hayes (A)
X6006/7912

- **Human Capital Management Office**
  Joseph Stankovich
  X8506
- **Knowledge Management Office**
  George Albinson
  X7376
- **Business Interface Office**
  Anthony Sebasto (A)
  X6198
- **War-fighter Central**
  MAJ Dean
  X1908
- **Strategic Management Office**
  Joe Brescia
  X2326
- **PM EM Gun**
  LTC Stephanie Foster
  X9759

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Phone Numbers: COMM: (973) 724-XXXX
DSN 880-XXXX

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ARDEC – Supporting Four LCMC's

Assigned/Direct Support
Coordination

Department of the Army (DA)

AL&T

AAE

AMC

RDECOM

ARDEC

TACOM LCMC

TACOM ILSC Elements
Weapon Arsenal & Depots

PEO Soldier
PM SW

PEO GCS
PM JLW155
HBCT
Stryker

PM Force Projection
PM Joint Combat Support Systems
PM Tactical Vehicles

Guns Ammo & Fire Control
Technology Development
Technology Insertion
Technology Sustainment

Communication Electronics LCMC

Aviation Missile LCMC

JM&L LCMC

PEO AMMO
PM MAS
PM CAS
PM CCS
PM JS

JMC
MLRC
DAC
Ammo Plants & Depots

2007 Award Recipient

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

ARDEC at a Glance

- Established "Center of Mass" for Armament Systems and Munitions for Joint Services
- ARDEC is the largest tenant at Picatinny Arsenal
  - Over 800 Buildings/64 Laboratories
- Proven track-record supporting transition of technologies to the field;
  - 18 Materiel Releases in FY 07, 8 Materiel Releases in FY 08
  - 16 Urgent Materiel Releases FY 07, 12 Urgent Materiel Releases in FY08
- ARDEC Gov't Personnel ~ 3348; 1145 new hires since FY99
  - Picatinny Site = 2887
  - Benet (Watervliet Arsenal) = 242
  - Rock Island Arsenal = 153
  - Adelphi & APG = 66
- >$100M invested in "World Class" experimental R&D facilities since mid-90's; Additional $75M planned
- Strong partnerships with Industry, Academia, and other Government agencies - Growth and Success through Cooperative Research and Development Agreements (CRADAs) = 121
- Intellectual Property (as of 4Q08):
  - Invention Disclosures – 58
  - Patent Applications – 164
  - Patents Issued – 11

  Patent License Agreements = 14 (as of 4Q08)
- In-house rapid prototyping initiatives demonstrating new desired capabilities, supporting production prove-out and initial fielding demands
  - > $100M Tech Base portfolio addressing Joint needs (Core Tech Base/ManTech only; does not include SBIR or Congressional Plus-ups)







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ARDEC's Core Competencies

Advanced Weapons Systems

- Indirect Fire
- Direct Fire
- Scalable Effects
- Non-Lethal
- Ammunition
  - Small Caliber
  - Medium Caliber
  - Large Caliber
- Directed Energy
- Remote Weapons
- Insensitive Munitions
- Fuzes
- Telemetry
- Precision Armaments Components
  - Grenades
  - Maneuver Support Munitions
  - Demolitions

Advanced Energetics, Warheads & Ammunition

- Propellants
- Explosives
- Pyrotechnics
- Warheads
  - Kinetic Energy
    - EFPs
    - Fragmentation
  - Chemical Energy

Fire Control

- Battlefield Digitization/SW Applications
- Embedded Systems SW
- Firing Tables
- Firing Tables: Ballistics
- Automated Test Systems

Logistics

- Ammunition Logistics RDTE
- Battlefield Tools and Equipment

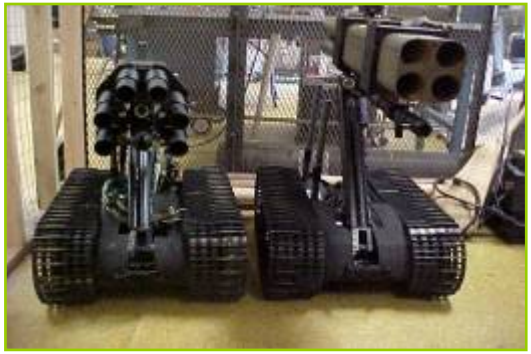
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Significant Technical Accomplishments

Development

TALON- US Army's First Functioning Lightweight Weaponized Robotic Platform



Key Product Transition To PEO XM395 Precision Guided Mortar Munition (PGMM)







Fielded for SOCOM

84mm High Explosive Dual Purpose & 84mm Area Denial Munitions For Multi-Role Anti-Armor Antipersonnel Weapon (MAAWS)



HEDP 502 IM

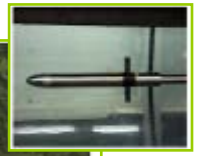




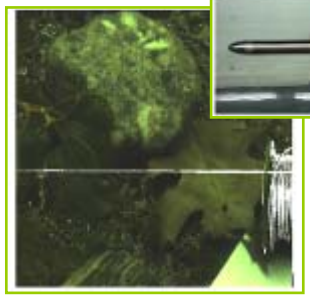
ADM 401 Flechette

New Extra Large 7.5" EFP For M303 Special Operations Demo Kit

Future



Autonomous Projectiles



Hyperspectral Imaging Devices

Fielded for Army, Marines



World's First 81mm M816 IR Mortar Illuminating Cartridge

M107 .50 Cal Sniper Rifle



Enduring Freedom URGENT Releases



M898 Sense & Destroy Armor (SADARM)

Non-Lethal Capability Set

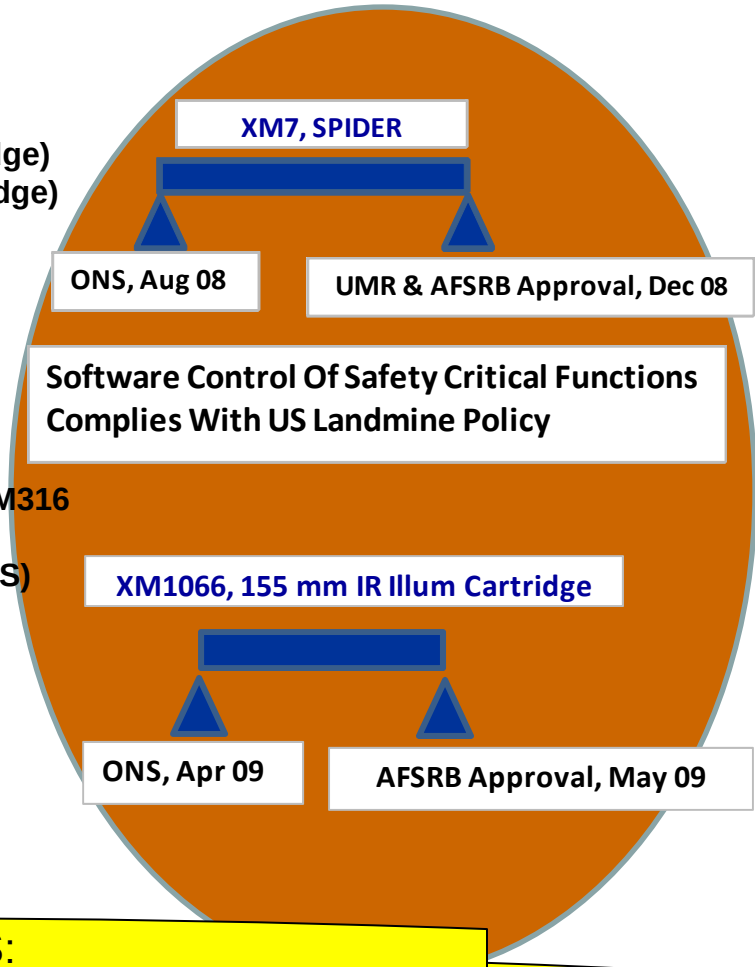


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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Army Fuze Safety Review Board (AFSRB) Support

- 2008 & 2009 Fuze Safety Certification (TC and Materiel Release)
  - GMLRS, Unitary, XM31E1
  - P-SDF, XM1161 & XM1162
  - MI-RAMS, XM156
  - Non-Lethal Bursting Grenade, XM104
  - Electronic Time Fuze, M762/M767 (for use with 105mm IR Cartridge)
  - M762/M762A1 & M782 MOFA (for use with 105mm HE PFF Cartridge)
  - Grenade Rifle Entry Munition, M100
  - BTV-1 EL Diversionary Hand Grenade, MK13 Mod 0
  - Electronic S&A&Fire GMLRS Unitary, M31A1
  - e-SDF, 105mm, M234
  - M762/M767A1 (For Use With 105mm DPICM)
  - Multi-Role Anti-Armor Anti-Personell Weapon System (MAAWS)
  - M762 / M762A1 (For Use With 155 mm, XM1066 IR Illum Projo
  - Time Delay – Sympathetic Det (TD-SYDET) and Trainer, M153 & M316
  - Dual Safe Fuze for AT4CS-RS 84 mm HEAT
  - Magneto-Inductive Remote Activation Munition System (MI-RAMS)
- 2008 & 2009 UMR & Approval Letters
  - TOW Bunker Buster Missile System
  - M820 Hellfire AGM-114FA Missile
  - XM7 Spider (1st to use software for safety critical functions)
  - MK14, Anti-Structural Hand Grenade
  - XM282 Multi-Purpose Penetrator Rocket Warhead
  - XM 1066, 155 IR Illum



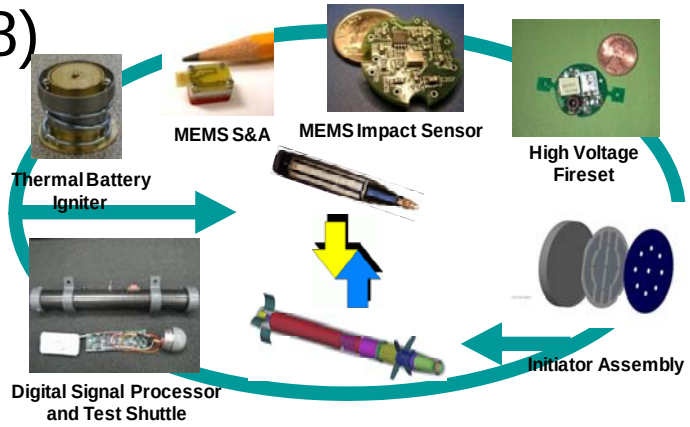
ARDEC FOCUS:
Deliver Safest & Most Capable Fuze Solutions To The Warfighter

Malcolm Baldrige National Quality Award 2007 Award Recipient

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

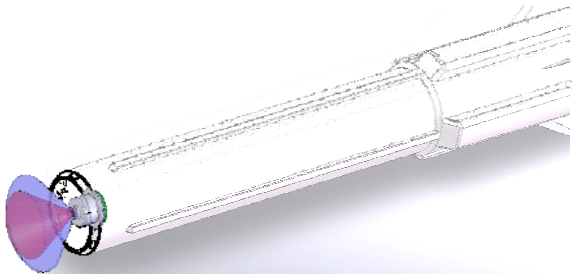
ARDEC Fuzing Technology Initiatives

- Fuze and Power (FAP) ATO (2005-2008)
  - Multi-Point Initiation
  - Proximity Sensors
  - MEMS Technology
    - S&A's & Environment Sensors
  - Power/Energy Sources



- Scalable Technology for Adaptive Response (STAR) ATO
  - 250 mm GMLRS, 105 mm Precision, 30 mm Airburst
- Kinetic Energy-Active Protection System Target Detection Device (KE-APS TDD) ATO
- Advanced Munitions Technologies ATO
- DoD Fuze Technology Initiative



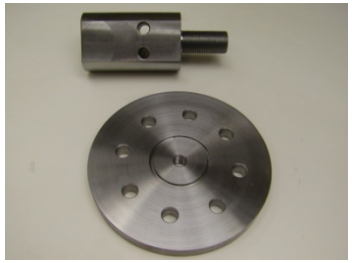
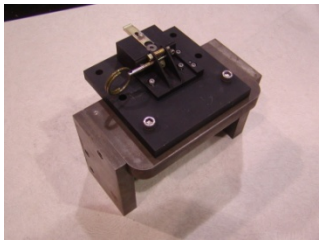


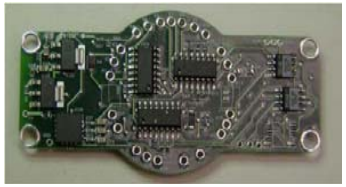
Malcolm Baldrige National Quality Award 2007 Award Recipient

ARDEC In-House Fuzing Capabilities
Fuze Development Center

Mission: To Accelerate New Technology To The



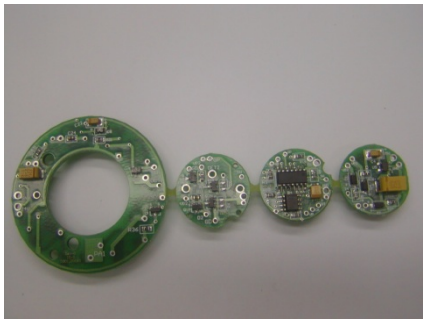
Capabilities for Rapid Prototyping:

Custom Circuit Card Design and Fabrication
Automated Surface Mount Assembly
Real-Time X-Ray Inspection
Environmental Test
Optical Strain and Stress Measurement
Stereo lithography
High Speed Spin Stand
Machine Shop



Current Projects Supported:

M208 Smoke Pot Fuze
SMADSNET
Rattlesnake
Artillery Training Kit
M228 Support
M762 Training Fuzes

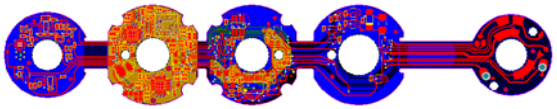



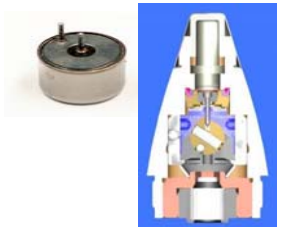
Malcolm Baldrige National Quality Award 2007 Award Recipient

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

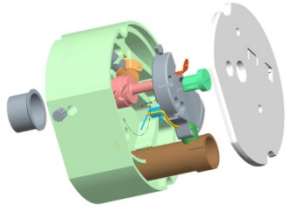
Fuze Technology Integration

- Technology Insertion To Current Munition Items
- Addresses Industrial Base Single Point Failure Issues
  - Risk Mitigation:
    - Battery Aging
    - M734A1 Digital Signal Processor (Alternative Design)
  - Block Upgrades:
    - Standardization of Hand Grenade Fuzes
    - 30mm Increased sensitivity M759 Fuze
    - Mortar S&A enhancements
- PEO Ammunition / User Payoff:
  - Insert Current Technology Into Today's Munitions
  - Preclude Obsolescence By Incorporating Component Technology
  - Provide Safer, More Reliable and More Lethal Munitions









Summary

- **Global Leader In Armaments Technology Solutions**
- **Provide Exceptional Customer Satisfaction**
  - **We work with soldiers:**
    - **develop new armaments systems,**
    - **improve fielded systems**
    - **quickly solve field problems**
- **State of the Art Fuzing Capabilities**
  - **In-House Facilities**
  - **S&T Technical Expertise**



Providing Increased Capability
to the Warfighter

Flexible, Agile, Innovative, and Responsive

APPROVED FOR PUBLIC RELEASE

DTRA Counter WMD Technologies

Fuzing & Instrumentation Technology Overview

Presented at
53rd Annual NDIA Fuze Conference
20 May 09

Danny R. Hayles
Technical Director
Hard Target Defeat Branch

APPROVED FOR PUBLIC RELEASE, DTRA PA CONTROL #09-198

Outline

- Mission & Campaigns
- Requirement for Hard Target Fuzing
- Current Fuzing and Instrumentation Technology Thrusts
- Summary

APPROVED FOR PUBLIC RELEASE, DTRA PA CONTROL #09-198

DTRA Mission & Campaigns

Mission:

...reduce the threat to the United States and its allies from Weapons of Mass Destruction (CBRNE) by providing capabilities to reduce, eliminate, and counter the threat, and mitigate its effects.

Functions:

Conduct RDT&E programs…in areas related to WMD and designated advanced weapons to include…WMD-related targets and the entire class of hard and deeply buried facilities.

Campaigns:

Campaign 5: Transform the Deterrent - support the COCOMs' ability to hold WMD at risk through offensive means

Objective 5.2.1: …leverage advances in …intelligent fuzing… to counter the most difficult targets

Vision:

Develop, test, and demonstrate to the Warfighters reliable and effective solutions to defeat WMD and WMD-related functions protected in Hard and Deeply Buried Targets

Increasing Importance of Hard or Deeply Buried Targets

"Underground Facilities. The rising importance of hardened or deeply buried facilities to potential adversarial nations and non-national organizations is becoming more apparent each year. *Whether those nations and non-government organizations are classified as* ***rogue, major, or emerging powers, or terrorist groups****, their critical military, leadership and* ***national security assets are increasingly protected by these facilities. The growth and sophistication of Hard and Deeply Buried Targets*** *(HDBTs) is especially significant* ***among countries whose support for terrorism and potential possession of WMD constitute threats to world peace and U.S. Security****…Their* ***new and modified facilities incorporate features that make them more survivable against known U.S. weapons.*** *Moreover, these countries are exporting underground construction techniques, and construction equipment."*

Source: "Statement for the Record to the Senate Armed Services Committee", Lt Gen Maples, Director, DIA, 27 February 2007, Page 29

Need for Intelligent Robust Survivable Fuzes

- Intelligence uncertainties
  - Target
    - Layering
    - Material strengths
    - Construction (columns/beams)
    - Location of vital centers
  - Geology
- Optimize detonation location – dependent upon desired effect
    - Minimize collateral damage
- Limitations of time fuzes
    - Uncertainty in weapon & target models makes fuze setting predictions difficult







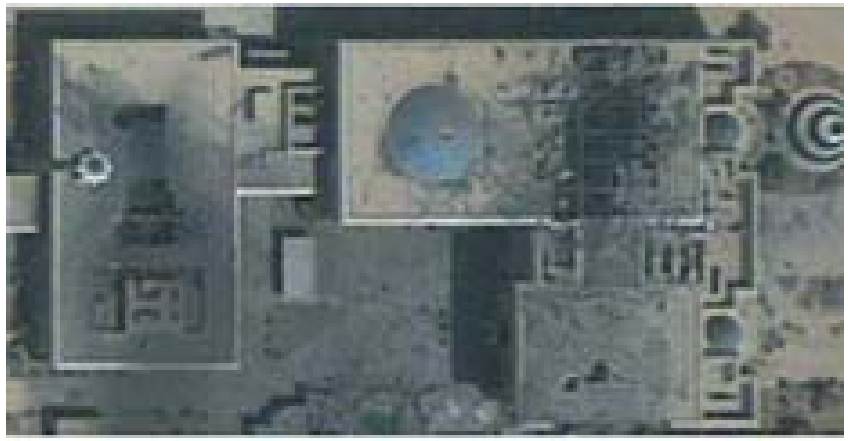

Hard & Deeply Buried Target (HDBT) Defeat Critical to Counter WMD Mission

- **Use of HDBTs is widespread among both hostile states and terrorists to protect WMD and WMD-related functions including:**
  - **Production, storage, research**
  - **Delivery systems**
  - **Command and control**
  - **National/terrorist leadership**

MOST VALUABLE ASSETS





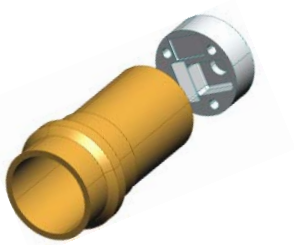


You can't defeat WMDs, if you can't defeat HDBTs!!

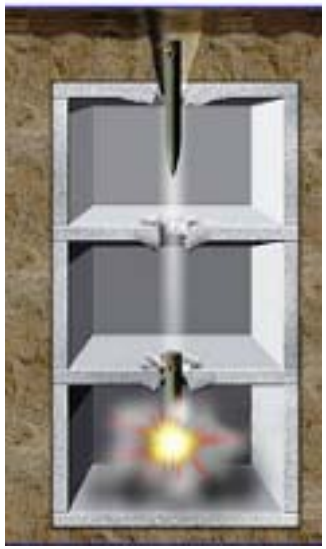
You can't defeat HDBTs, if the fuze does not survive!!

Fuzing and Instrumentation Technology Vision

- Develop and demonstrate innovative **SURVIVABLE fuze technologies** to support the defeat of WMD related facilities
- Develop **SURVIVABLE instrumentation packages** to support development of
  - New fuzes
  - BDI technology

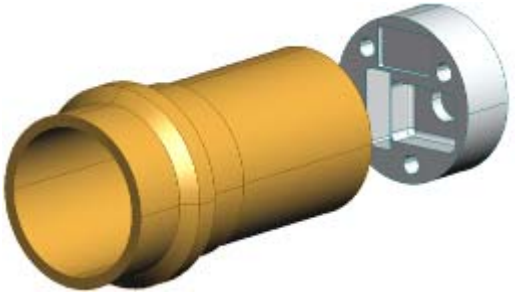


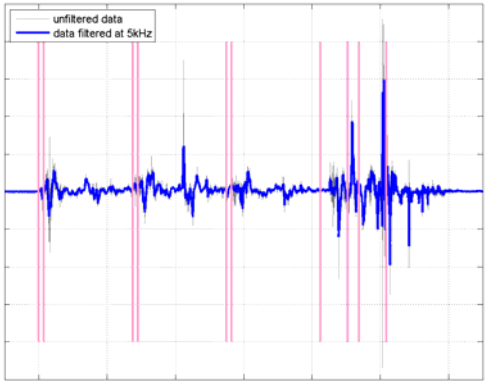




DTRA Fuzing and Instrumentation Technology Thrusts

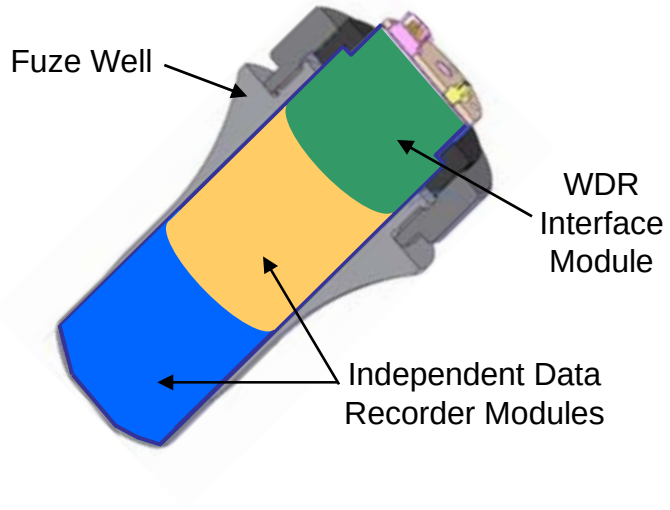
- Fuze Harsh Environment Characterization & Test Support
  - Fundamental understanding of forcing functions on the fuze and fuze components
  - System level aspects being pursued within the larger Community
  - Bottom Line: Need to be able to predict and test the multi-axis loads on fuzes





DTRA Fuzing and Instrumentation Technology Thrusts

- Recorders for Harsh Environments
  - OSD Hosted Data Recorder Workshop (Feb 09)
  - Weapon Data Recorder (WDR)
    - ICD Being Developed in FY09
    - Follow-up Workshop Planned for Spring 2010



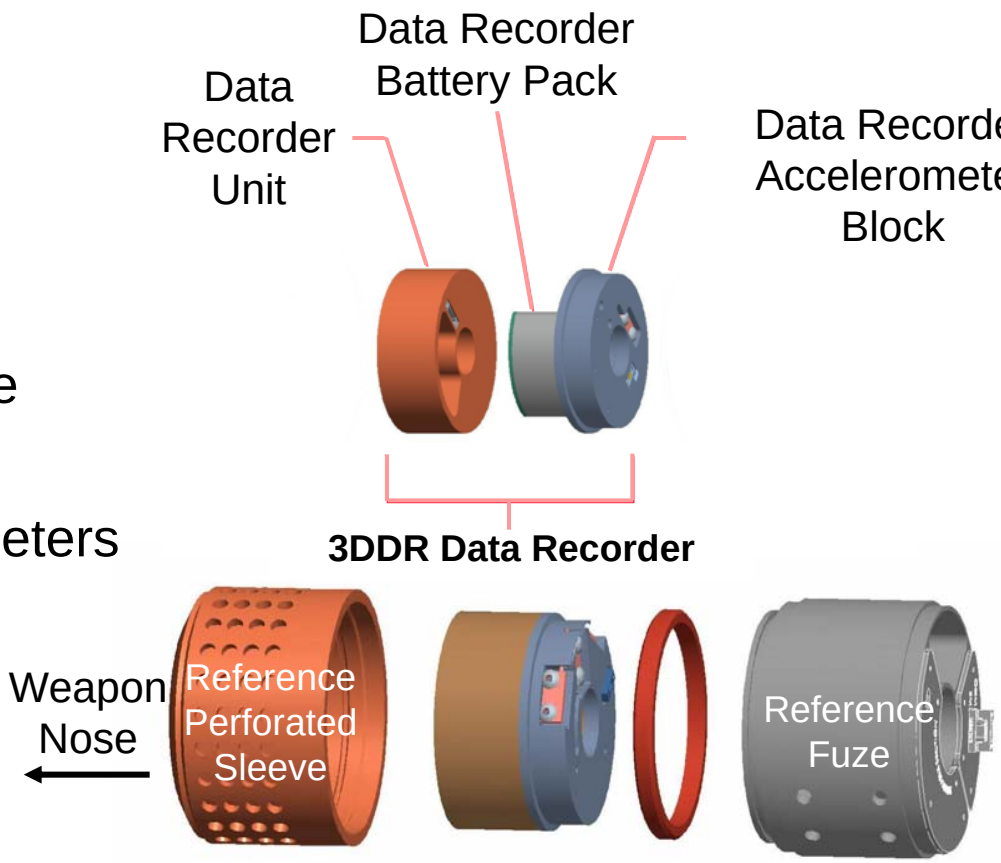
WDR Features

- 3” Data Recorder Instrumentation Package
- Size & weight of current legacy fuzes
- Standardized Robust/Reliable Interfaces
- Cantilever or Compression Mounted
- Independent Data Recorders
  - Threshold of 2
  - Goal of 3

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DTRA Fuzing and Instrumentation Technology Thrusts

- Recorders for Harsh Environments (Cont)
  - 3-Axis DTRA Data Recorder (3DDR)
    - Booster Cup Compatible
    - 3 Unit Design
    - Replaceable Accelerometers



Photos Courtesy of Sandia National Laboratory
Public Releasable: SAND # 2009-0918 P

DTRA Fuzing and Instrumentation Technology Thrusts

- Fuze **Survivability** Thrusts
  - Developing diagnostic fuze post impact module
    - Failure mechanisms of individual components
    - Component mounting techniques
    - Potting material characterization
    - Shock mitigation materials
    - Fuze system design techniques/architectures
  - Engaged in penetration community
    - Transfer functions through the various weapon system interfaces to assess the impact loading on the fuze
      - Explosive fill (live & inert simulate) material properties characterization
      - TCG-XI Concrete Modeling and Simulations Working Group
      - TCG-X and XI Collaboration Effort
    - Improving existing test protocols to increase fuze survivability confidence levels
      - Test beyond weapon system specifications for initial impact conditions
      - Sub-scale multi-axis tests
      - Full-scale multi-layer targets for flight testing

Summary

- Hardened or deeply buried facilities are becoming:
  - More important to potential adversarial nations and non-national organizations
  - Harder to defeat
- Capability to defeat HDBTs is critical to Counter-WMD mission
  - Fuze survivability is essential to defeating HDBTs
  - Smart post-impact burst point control required
- Fuze harsh environment characterization is essential
  - Predictive capability for fuze/fuze component survivability
  - Development of robust sub-scale multi-axis test protocol
  - Defining robust full-scale tests compatible with limited resources
- Focused on fuze & instrumentation survivability in harsh environments
  - Developing diagnostic fuze post impact module
  - Engaged in penetration community to work system level issues

Insensitive Munition Solutions for Anti-Structure Munition Grenade

by
Carl J. Campagnuolo, Vincent Gonsalves, Gerard Eilert,
William Cardenas and
William J. Andrews

USSOCOM

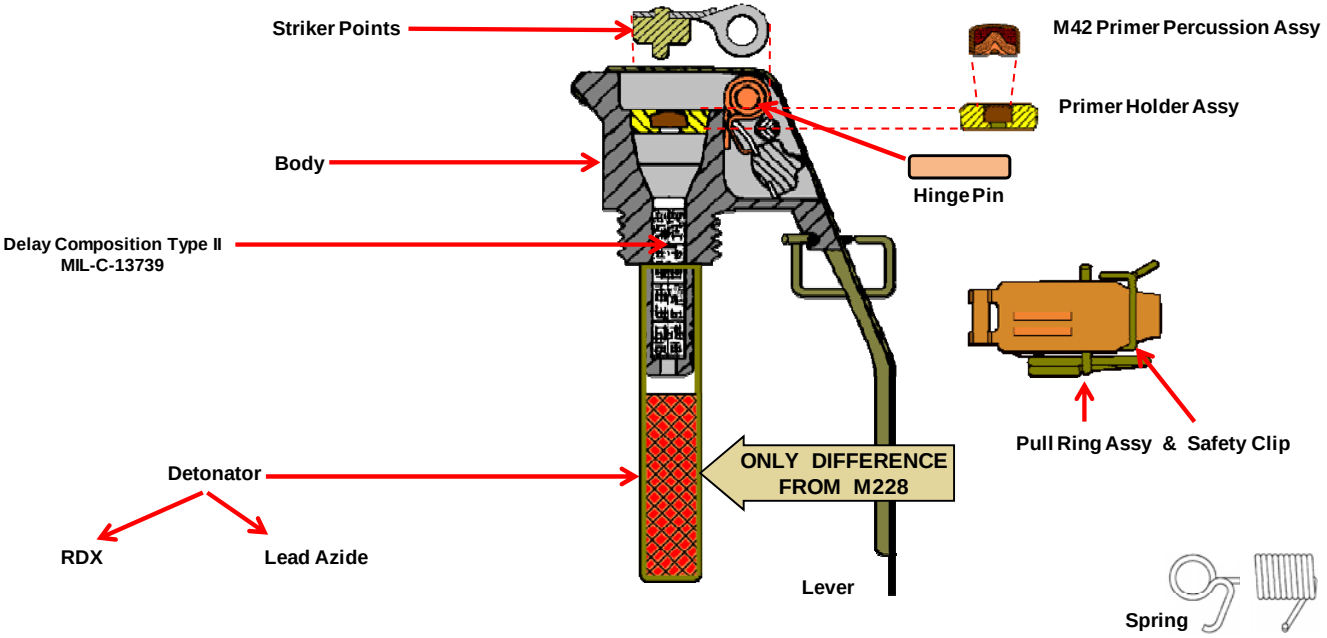
53rd Annual Fuze Conference
May 19-21, 2009

Grenades



M67 and ASM Grenades

M213 HE Hand Grenade Fuze



IM Test Results

- The current design fails all IM tests. This is primarily due to the sensitive energetics in the M213 Fuze (C70 Detonator).

IM Test Summary For M67 Hand Grenade							
Component	**H/C**	**FCO**	**SCO**	**BI**	**FI**	**SD**	**SCJ**
M67	**1.1**	**I**	**I**	**I**	**I**	**I**	**(F)**
* Reactions shown in Parenthesis ( ) are assessed, not based on actual test scores							

- Type VI: No Reaction
- Type V: Burn
- Type IV: Deflagration
- Type III: Explosion
- Type II: Partial Detonation
- Type: I Detonation

FCO: Fast Cook-off
SCO: Slow Cook-off
BI: Bullet Impact
FI: Fragment Impact
SD: Sympathetic Detonation
SCJ: Shaped Charge Jet

How to Solve the Problem

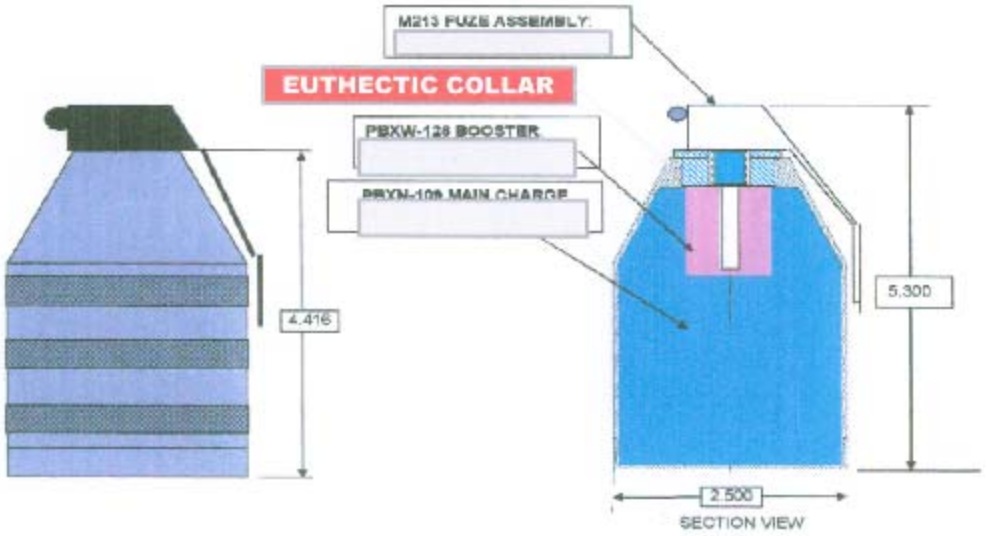
- Remove the fuze during SCO and FCO by replacing the fuze adapter with a eutectic metal that melts at about 240º F. Let the pressure from the burning PBXN-109 push the fuze out.

- This technique can be used for both the M67 and the ASM Grenade.

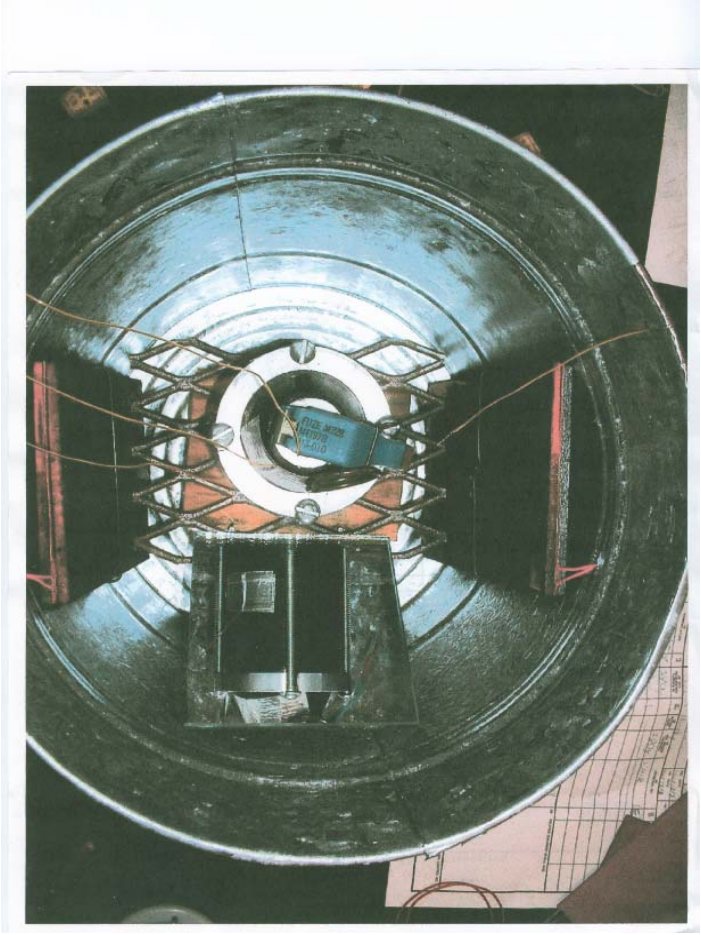
- The Comp B fill for the M67 Grenade must be replaced by an insensitive explosive such as PBXN-109, which burns rather than explode (as the ASM Grenade).

- Replace C70 Detonator in the fuze with a secondary explosive, i.e., PBXN-5. Secondary explosives burn rather than explode.

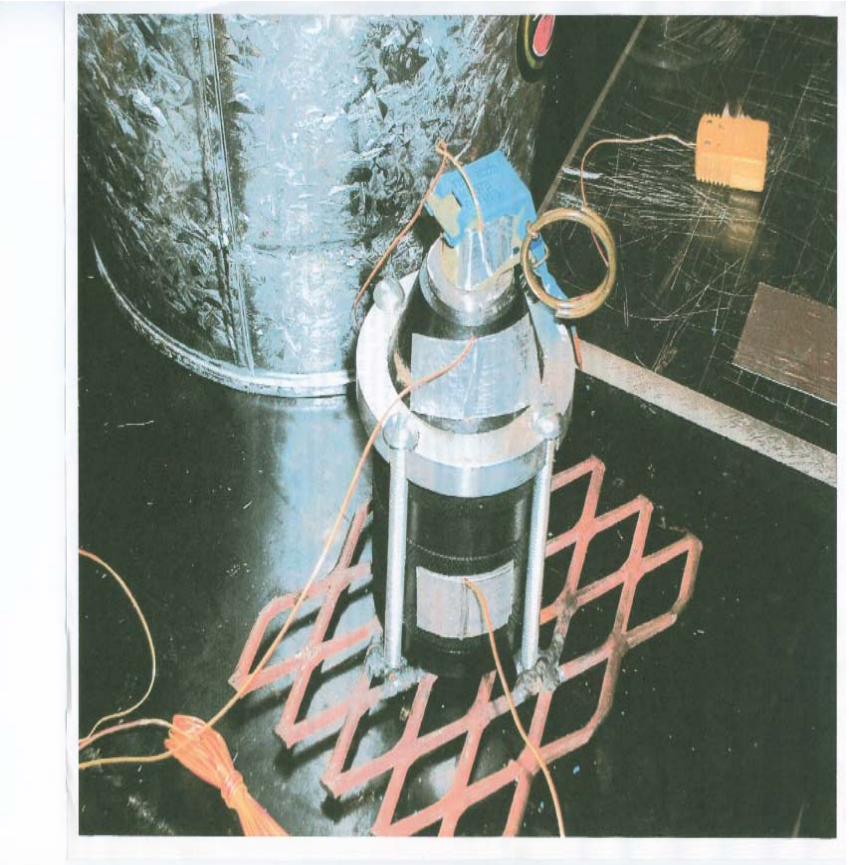
ASM Grenade


M213 FUZE ASSEMBLY
EUTHECTIC COLLAR
PBXW-128 BOOSTER
PBXN-109 MAIN CHARGE
4.416
5.300
2.500
SECTION VIEW

ASM Grenade, Slow Cook Off Test with M228 Fuze



ASM GRENADE SCO Test
M228 Fuze



ASM GRENADE SCO M228
Fuze Test Set Up

Post SCO Test, ASM Grenade M228 Fuze



Slow Cook Off ASM Grenade M228 Fuze



Event Video

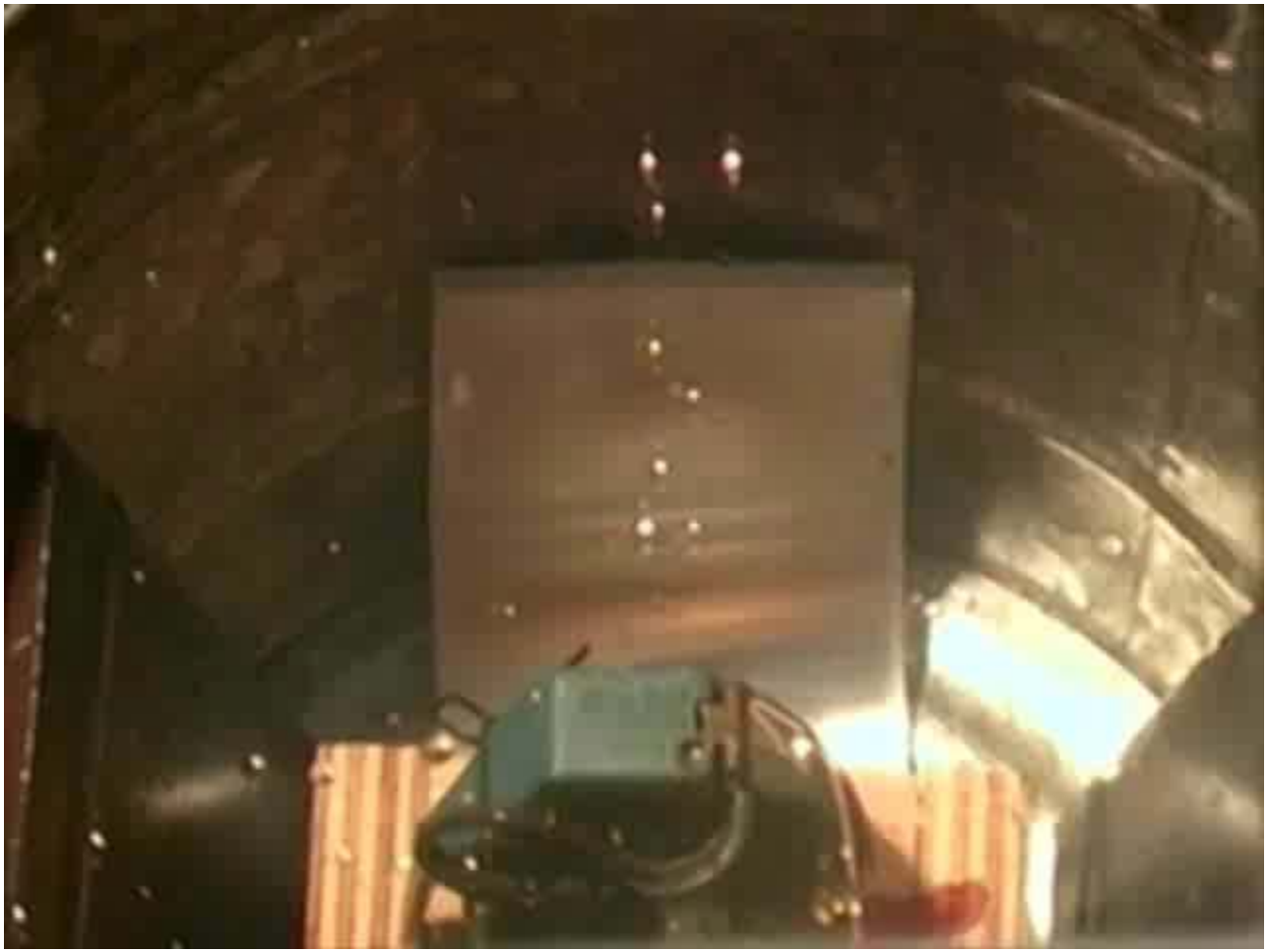
M67 Hand Grenade

Introduction

- M67 Hand Grenade not IM compatible
- Contains large quantities of lead based materials (primary explosives)
- Single Point Failure



M67 Slow Cook Off Test
M228 Fuze



Event Video

SCO Test ASM Grenade, M213 Fuze
Post Test Fuze



Post Test Fuze Ejected from the Grenade

Slow Cook Off M67 Grenade, M213 Fuze Post Test



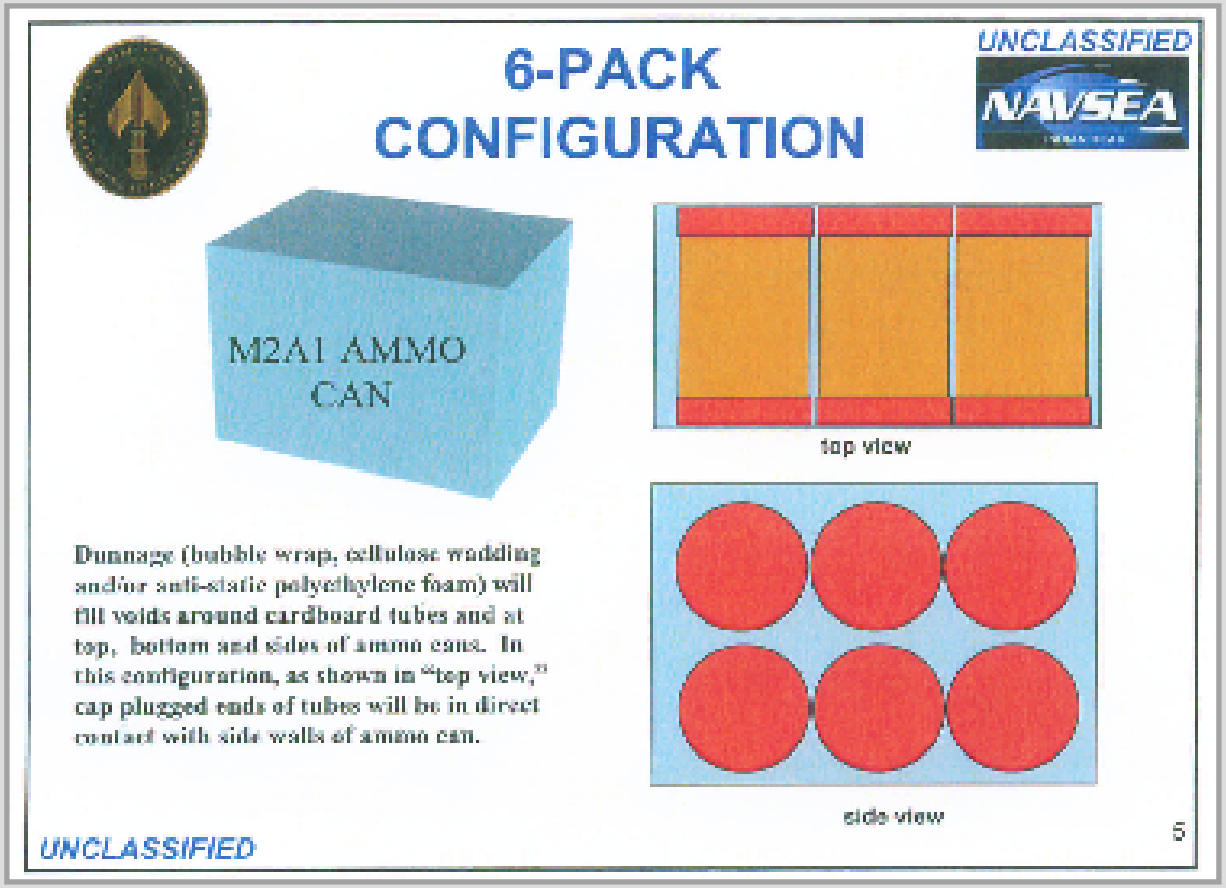
Fuze Ejected from the Grenade

Fast Cook Off ASM Grenade, M228 Fuze Post Test



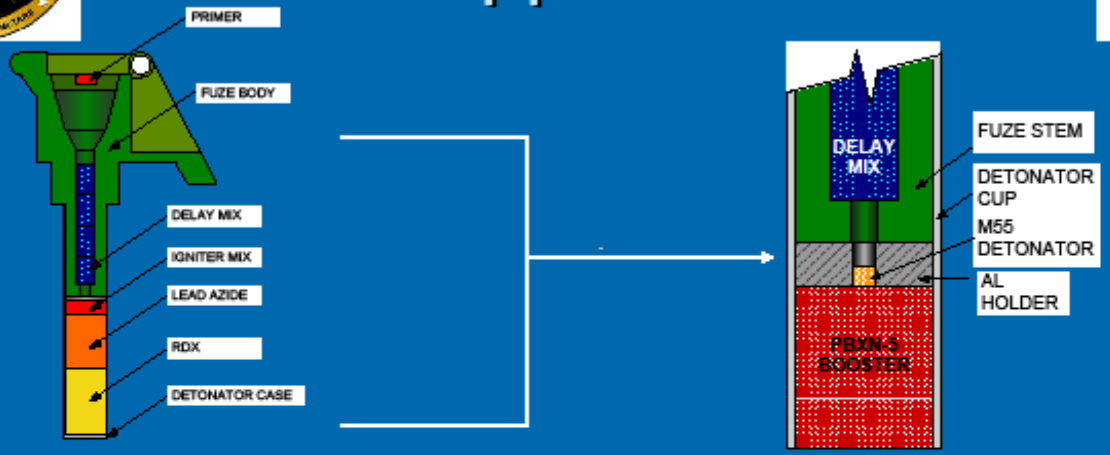
Fuze Ejected from the Grenade

ASM Grenade Container



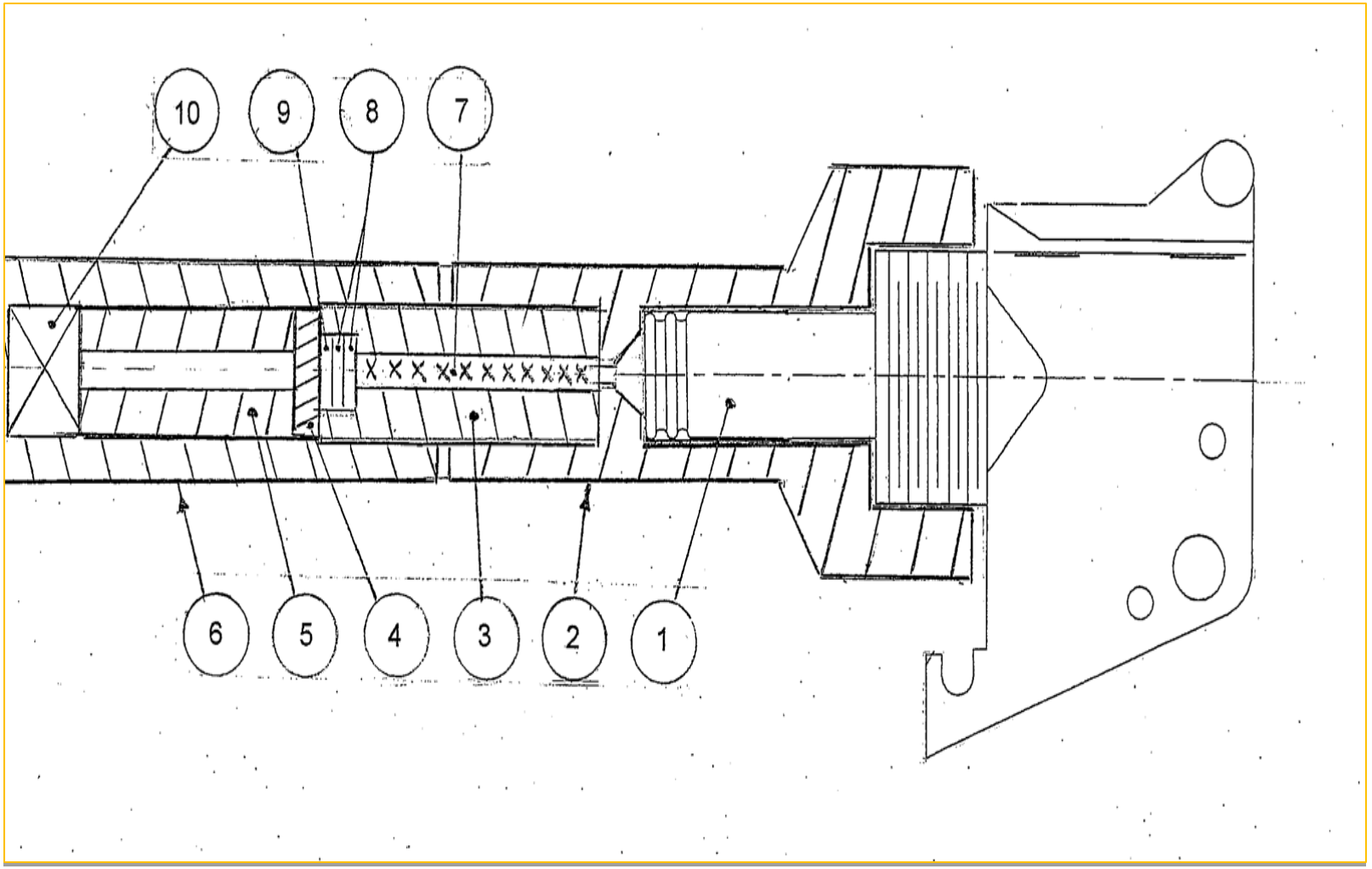
From 2008 Fuze Conference, G. Chang

Approach



- M55 Detonator to Booster
  - Reduced quantity of lead azide and lead styphnate
    - Improve Safety
  - Single point failure issue resolved

Fuze Column Improvement



NDIA Fuze Conference

Orlando, Florida

May 19-21, 2009

Fuze Technology Integration (FTI) Improved 30 mm

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

John T. Geaney

Fuze and Precision Armaments Technology Directorate

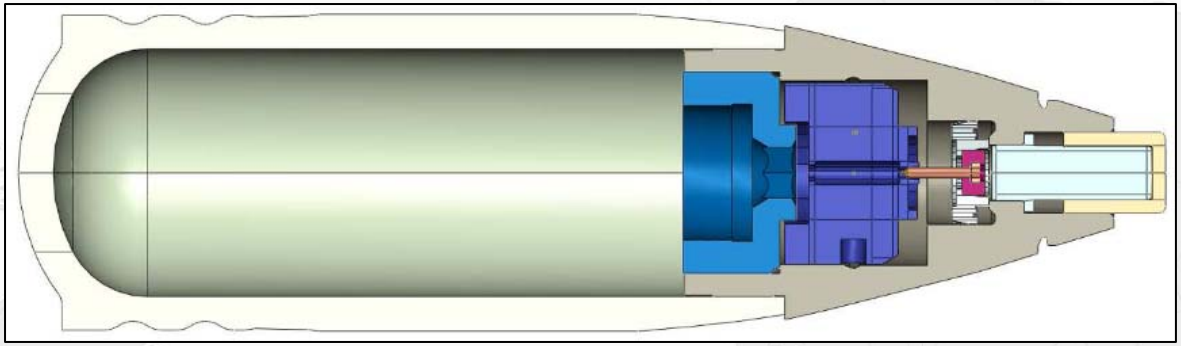
METC, ARDEC

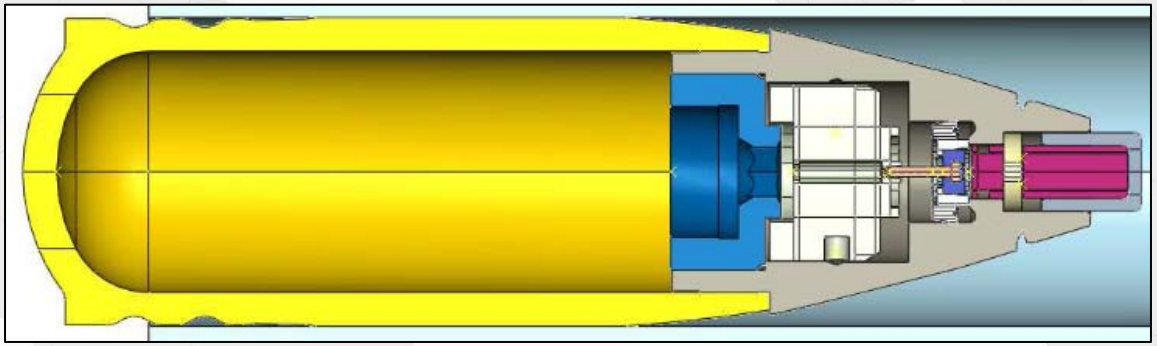
Picatinny Arsenal, NJ

Project Team Members

- John Geaney – Mechanical Design
- Barry Schwartz – Mechanical Design
- Stephen Recchia – Finite Element Analysis



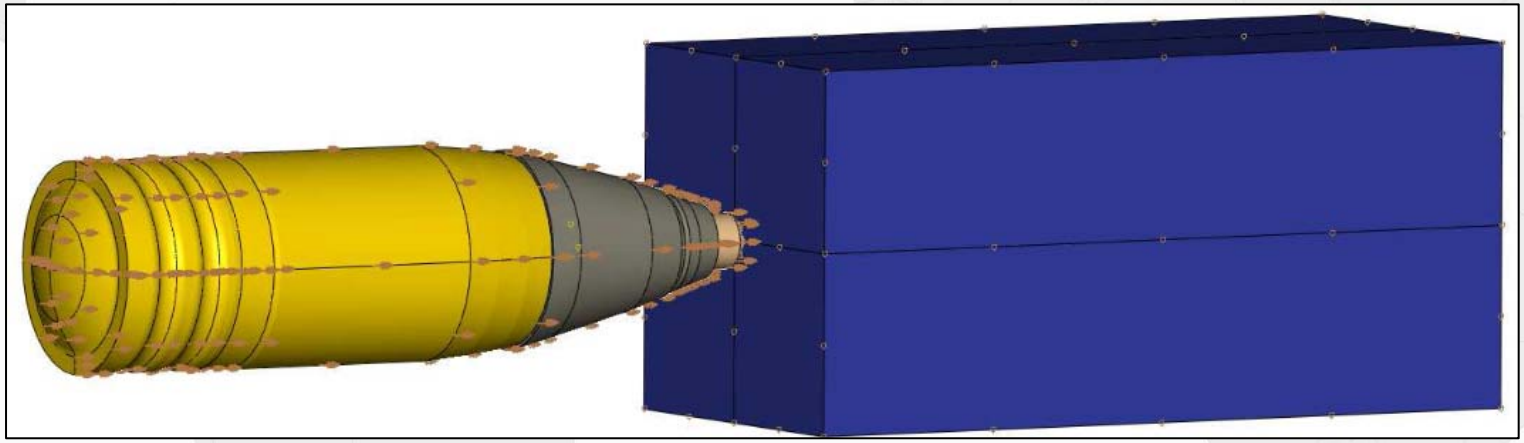






Background

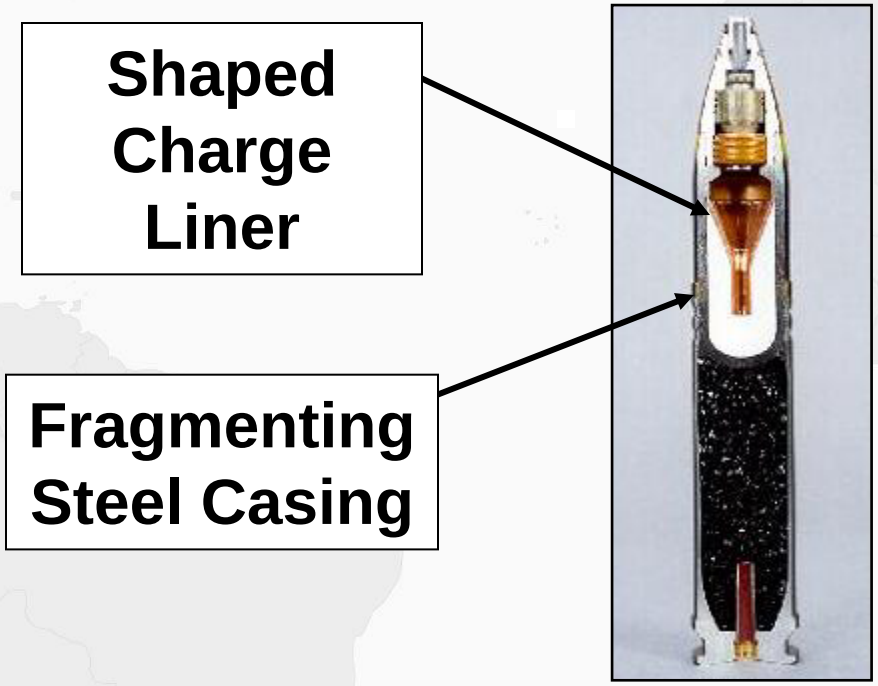
- A Fuze Division FTI project was initiated to improve the stab performance of the M759 fuze on the M789 30mm HEDP round.
- FTI projects apply modern technology to upgrade fuze systems in production
- The M789 30mm round is an Apache helicopter fired round designed primarily for anti-material and light armored targets



Background

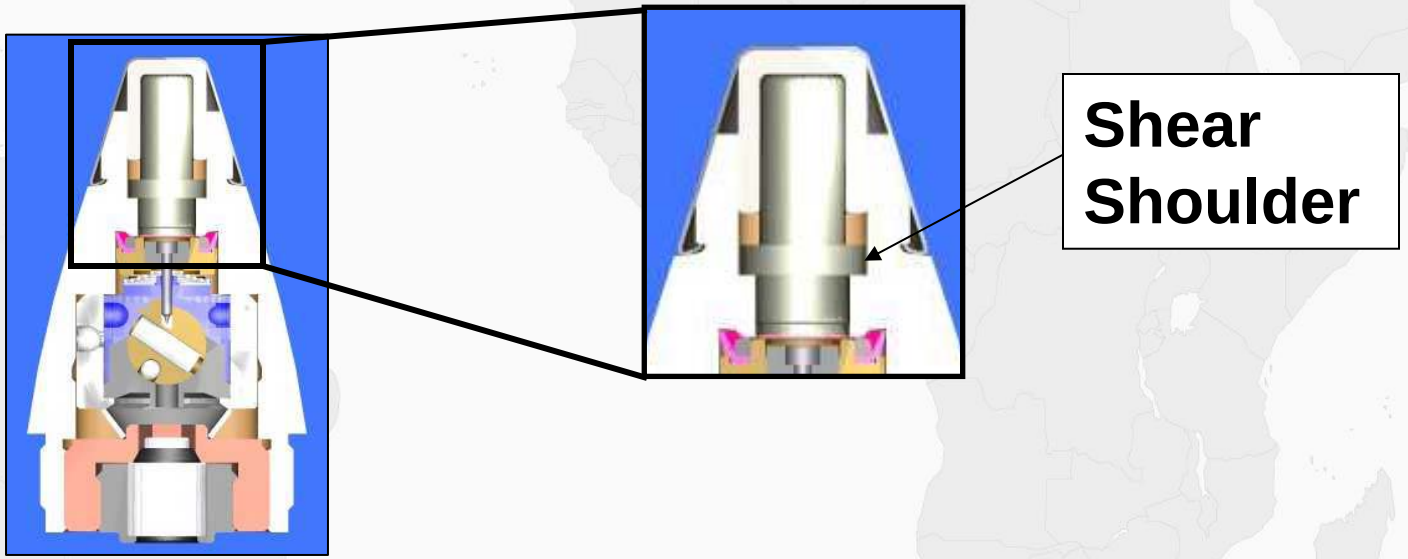
The M789 is a High Explosive Dual Purpose (HEDP) round

- Shape Charge effectively penetrates light armor
- Fragmenting steel casing neutralizes unarmored targets



Problem Statement

- Current design requires shearing a nylon shoulder on impact.
- Soft target impacts do not shear the shoulder, resulting in inertial detonation, deeper round penetration, and degraded fragmentation effectiveness
- Increased fuze sensitivity will improve impact performance



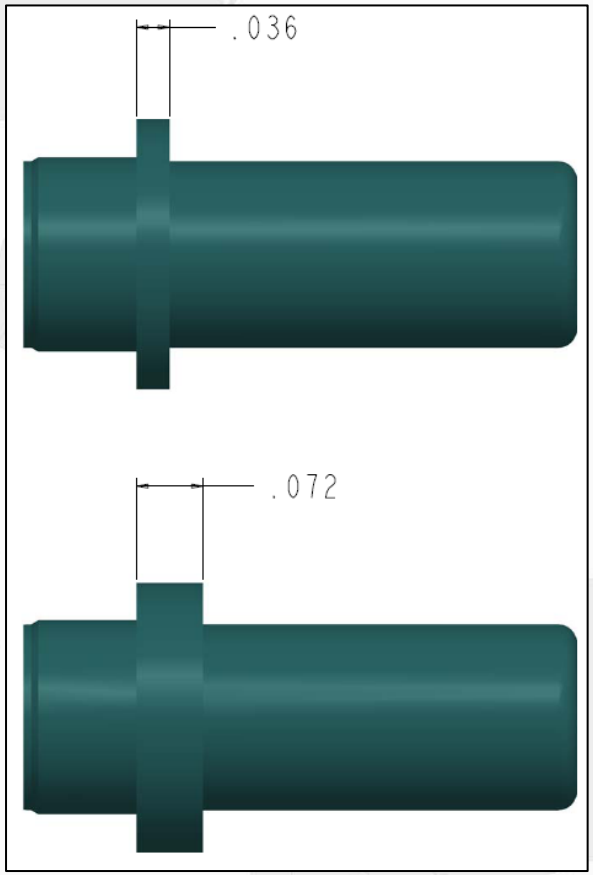
FTI Objective

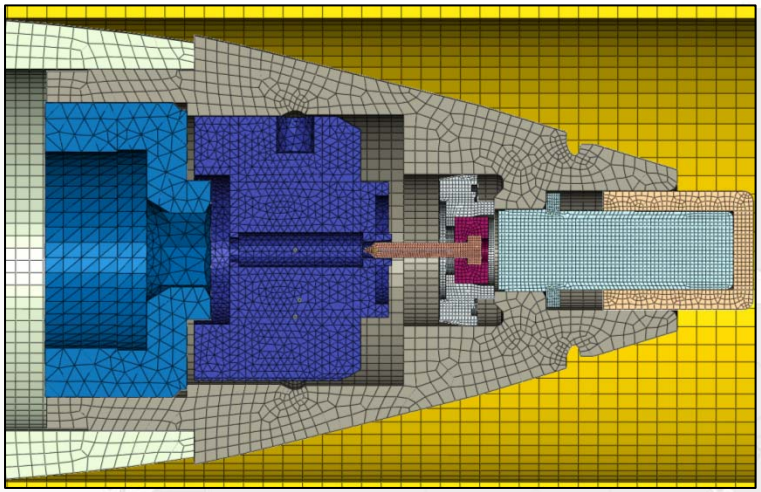
- Design fuze improvements to reduce impact detonation delay time in order to improve fragmentation in an anti-personnel application
- Utilize low cost components
- Minimize retooling impact to existing fuze

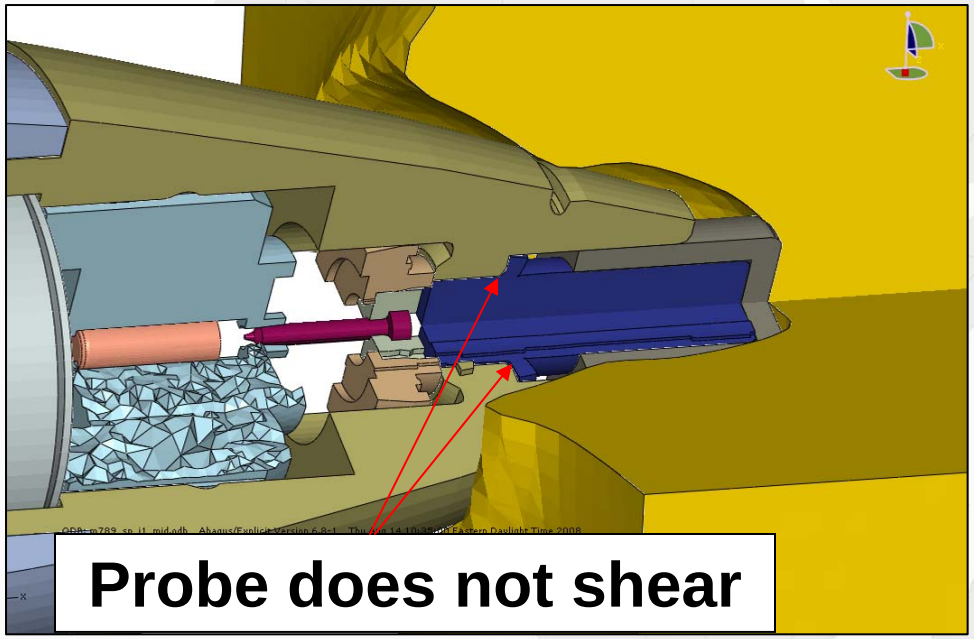
Concept Solution

Concept #1:

Reduce shear shoulder thickness to increase impact sensitivity





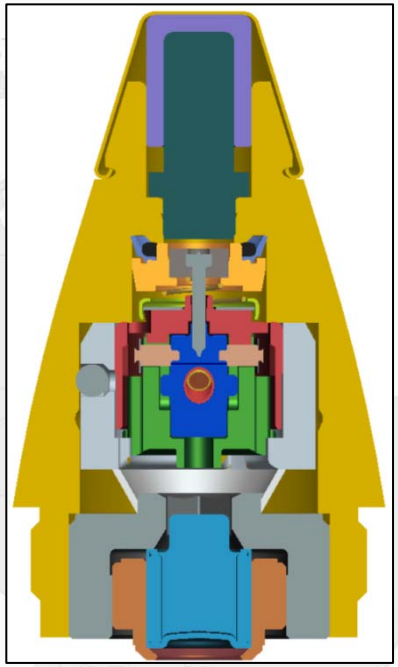


Concept Analysis

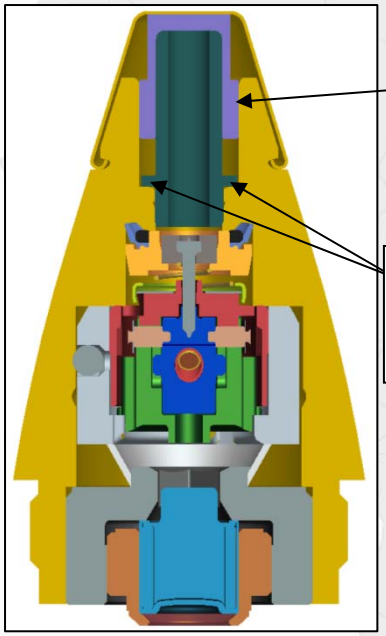
Concept #1

- Probe and confinement cup could be lightened to survive 100,000 g's during setback
- M&S analysis shows minimum shoulder thickness will not shear on impact with soft targets

Original Design



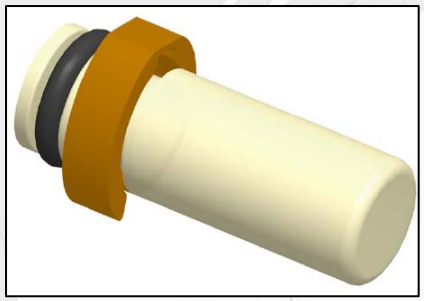
Concept #1

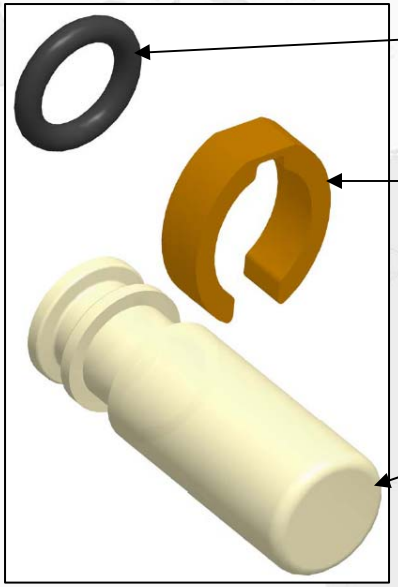


Concept Solution

Concept #2:

Replace shear shoulder with cartridge brass spin clip

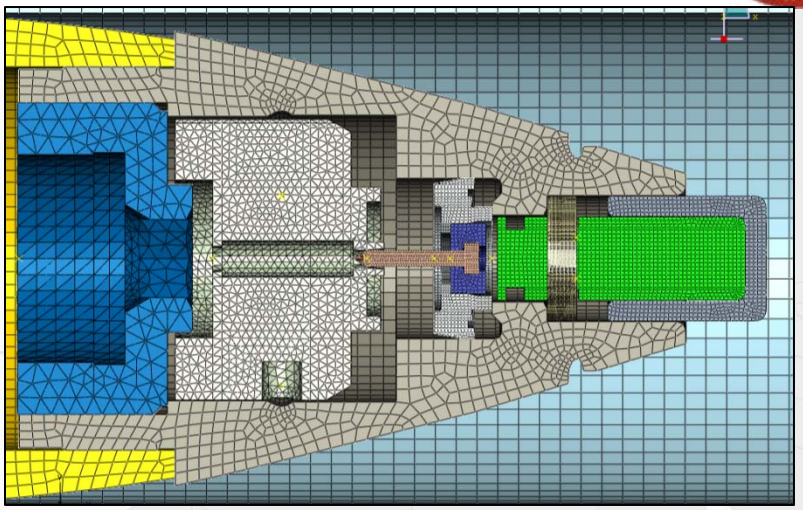


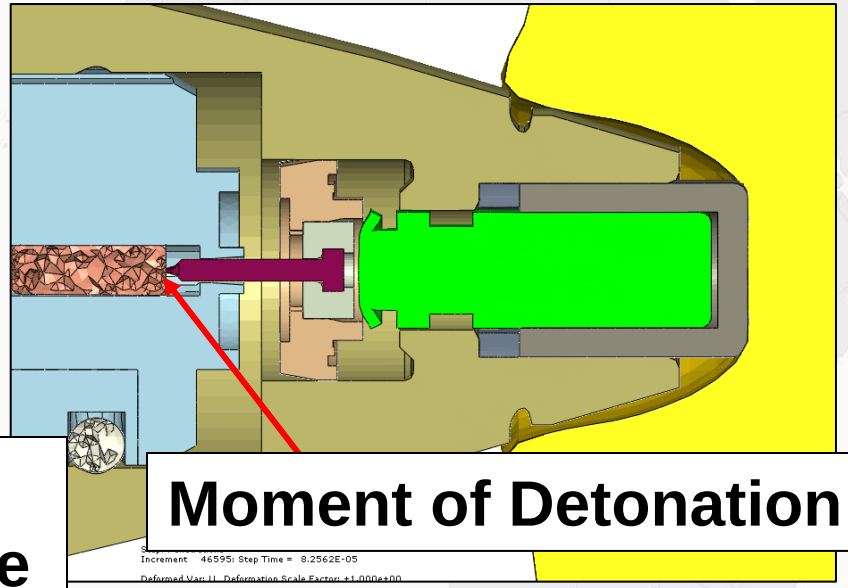


3.5mm O-Ring

Cartridge Brass Spin Clip

Improved Polycarbonate Probe





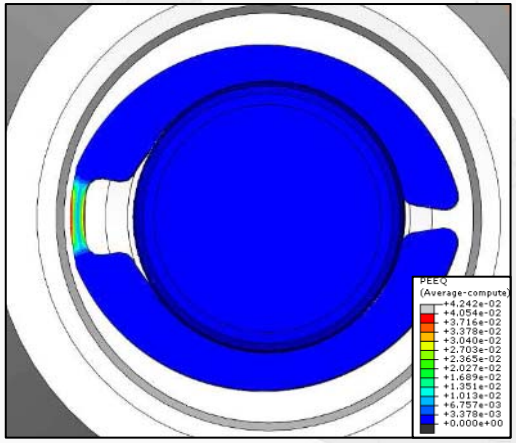
Moment of Detonation

Concept Analysis

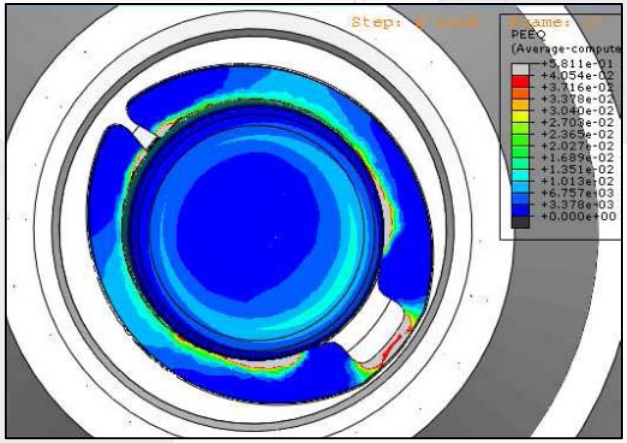
Concept #2

- M&S analysis shows
  - Spin clip survives peak setback acceleration of 100,000 g's
  - Spin clip opens at muzzle spin rate, 60,000 rpm

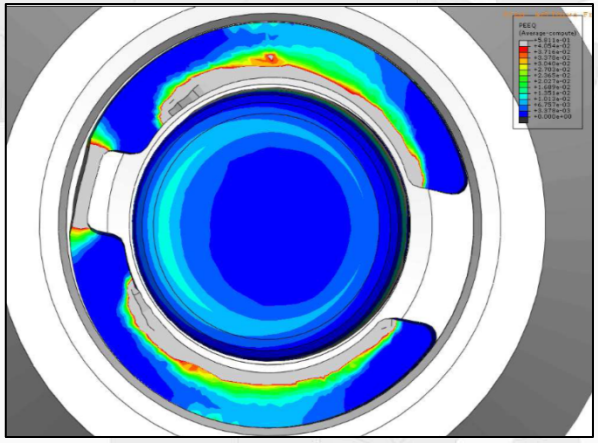
Pre Gun Launch



100,000 g Setback



60,000 rpm Muzzle Spin Rate



FTI Objective Analysis

Program objective was to reduce impact detonation delay time to improve fragmentation

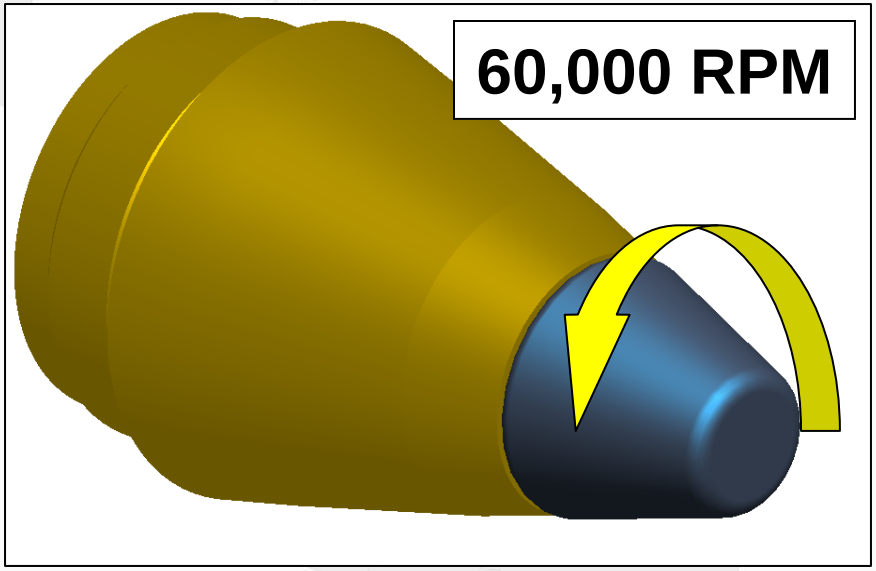
	Muzzle Velocity (2,670 ft/s)	Half Range Velocity (1,083 ft/s)	End Range Velocity (450 ft/s)
Current Design			
Detonation Time (ms)	0.048	0.200	>0.200
Penetration Depth (in)	1.500	4.000	>4.000
Improved Design			
Detonation Time (ms)	-	-	0.083
Penetration Depth (in)	-	-	0.280

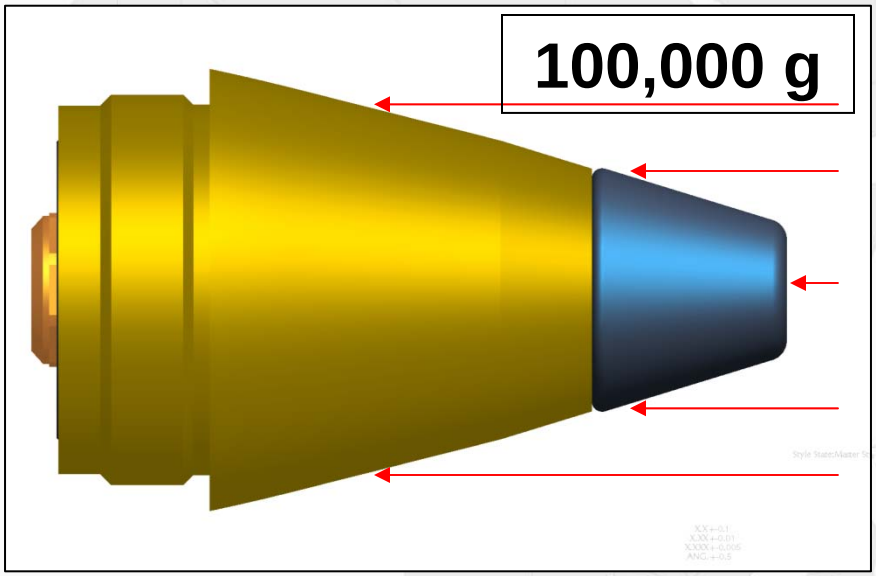
Fuze improvements decrease impact detonation delay time by a factor >2.4:1

Laboratory Testing

Laboratory testing performed at Picatinny Arsenal

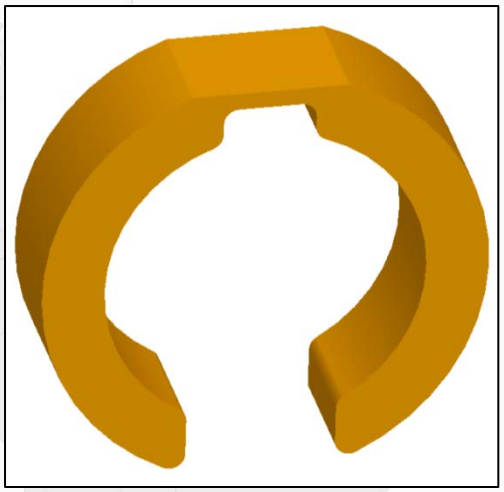
- High speed spin to tests confirm spin clips open at 60,000 RPM
- High g force air gun tests to confirm spin clips and probes can withstand 100,000g acceleration loads

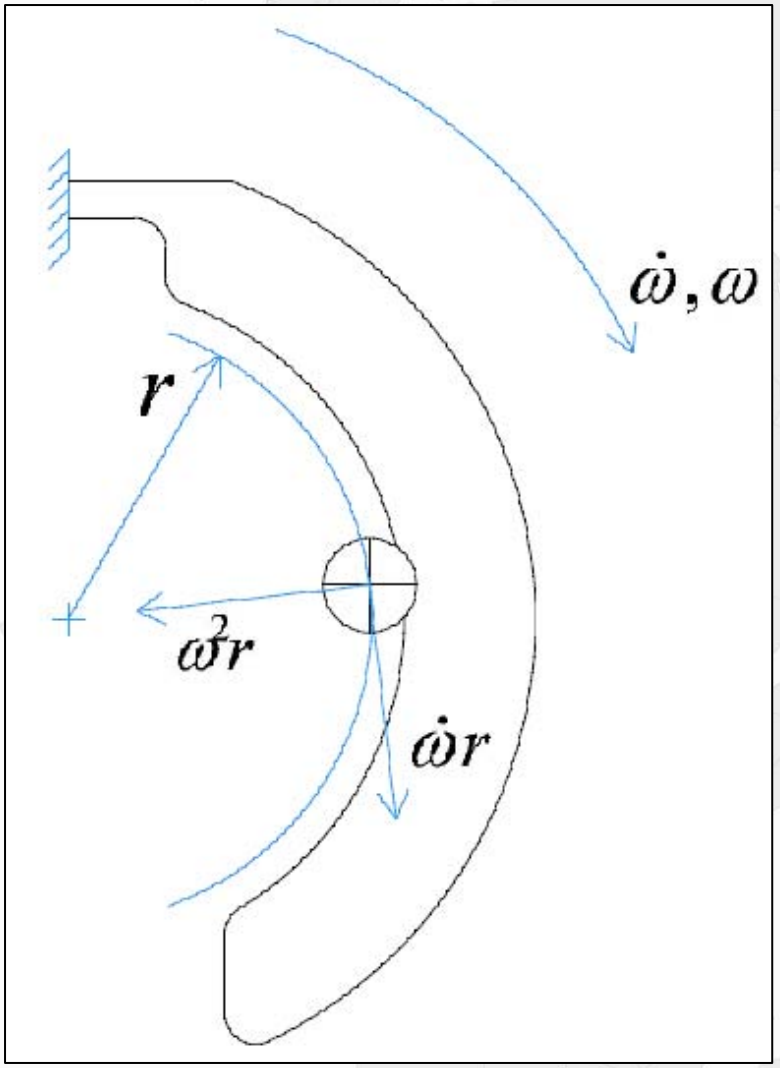




Spin Testing

- Spin clip operation is a function of angular velocity ($\omega^2 r$)
- Testing will verify clip opens at operating velocity, and determine operating velocity margin

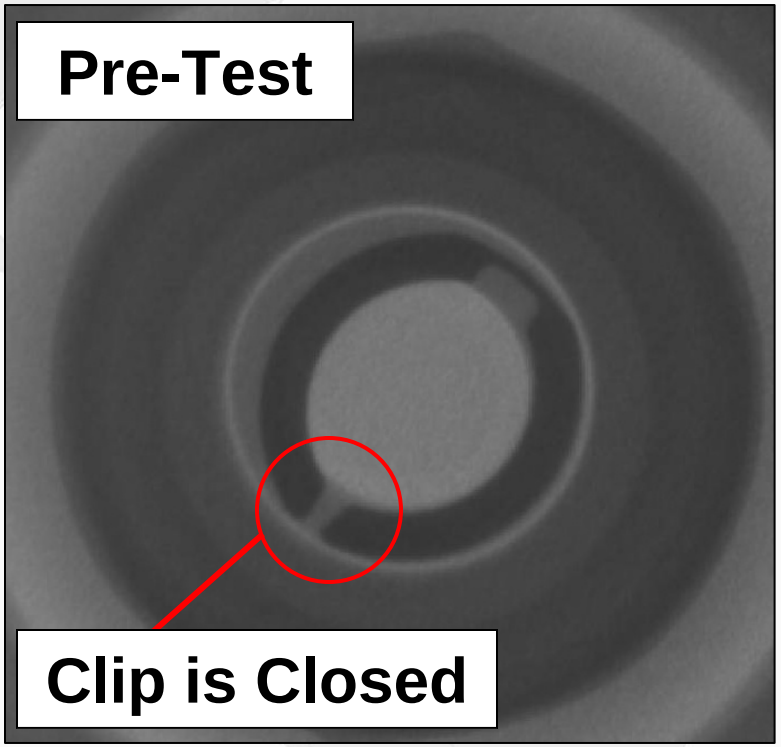


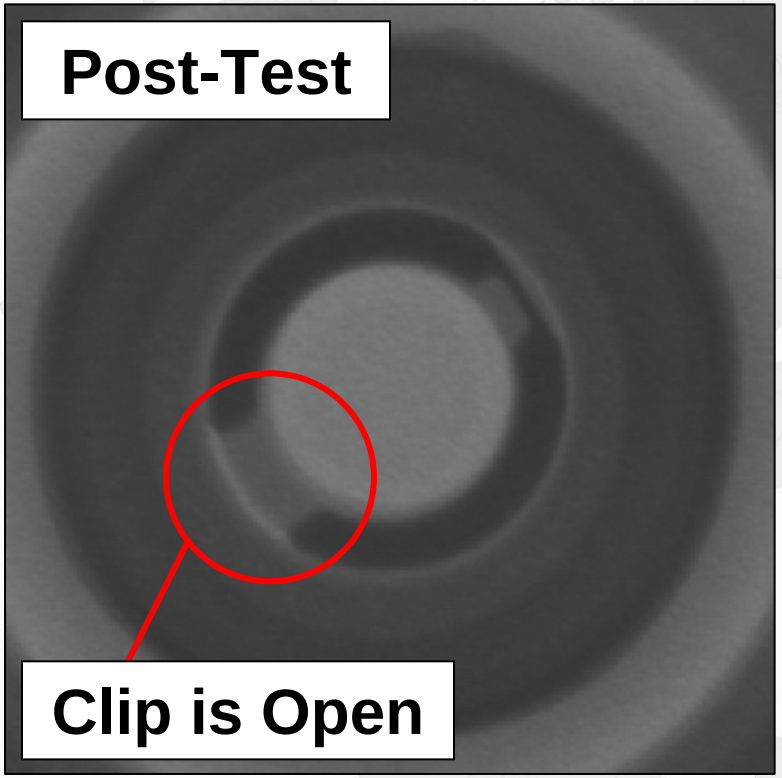


Spin Testing

Operating velocity spin tests performed on 5 samples

- **60,000 RPM**
- **100% success, all clips opened at operating velocity**

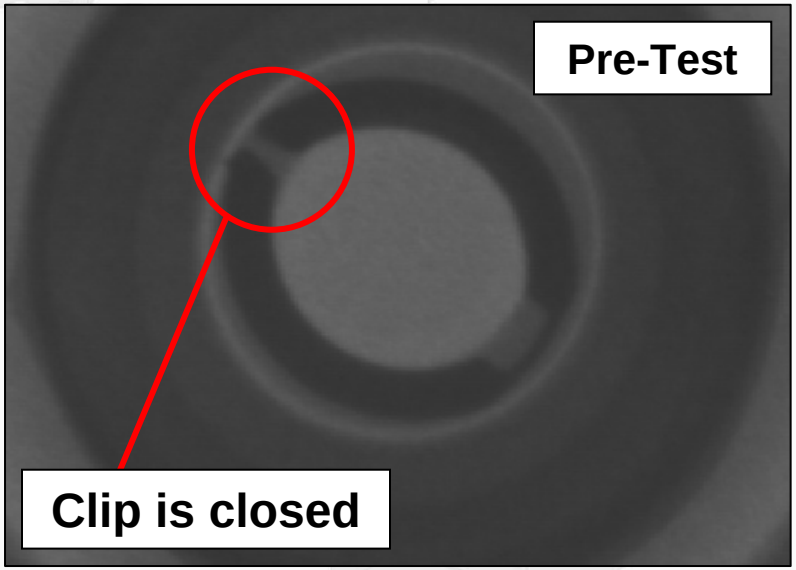


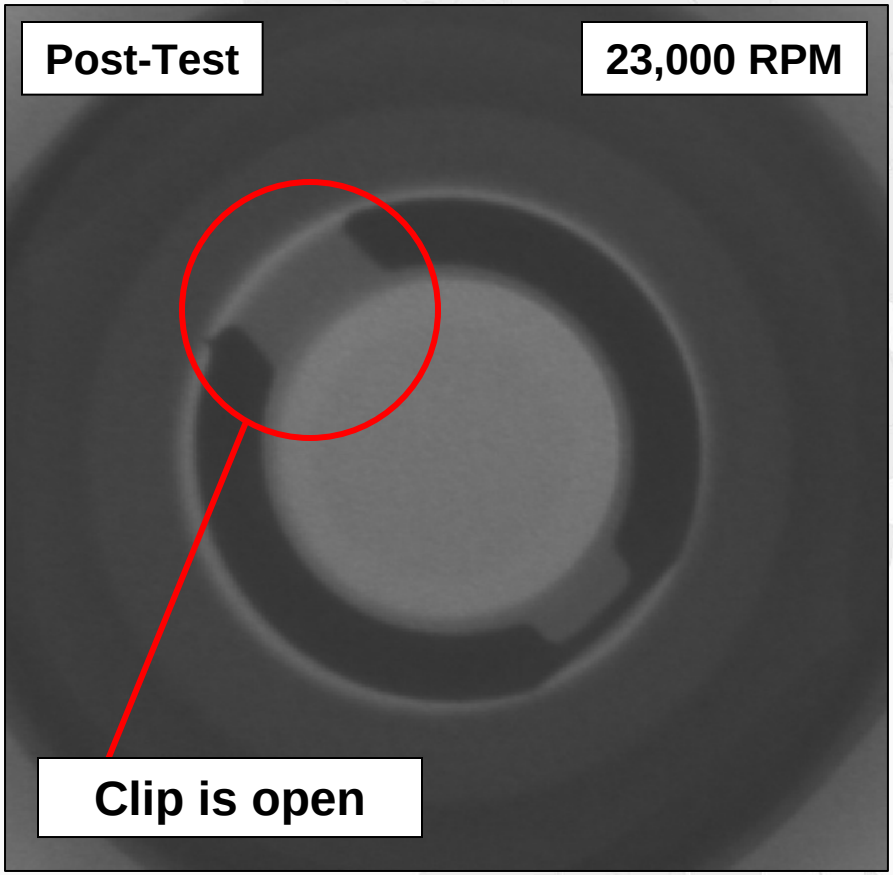


Spin Testing

Spin tests performed below 60,000 RPM operating environment to determine operational margin

RPM	Clip Operation
50,000	Opened
23,000	Opened
20,000	Did Not Open
15,000	Did Not Open
5,500	Did Not Open





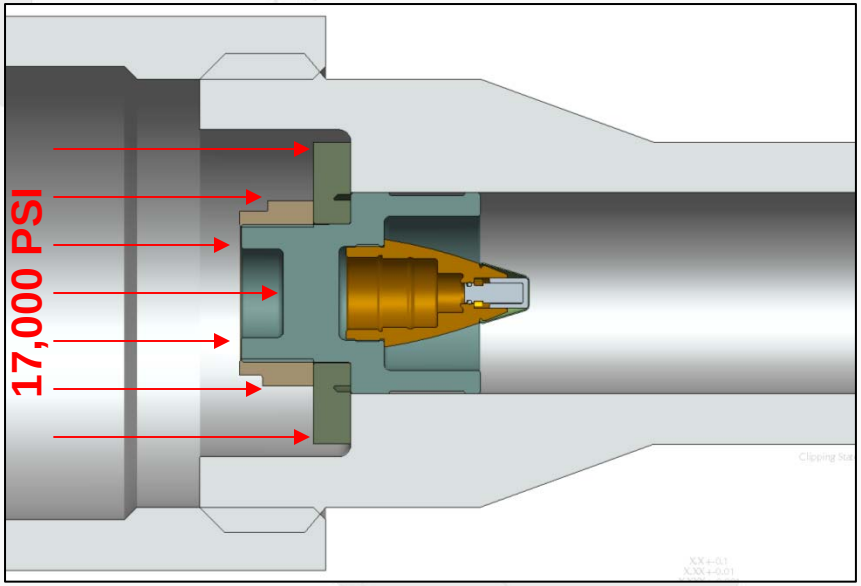
Spin Testing Conclusions

- Spin clip opens at operating velocity of 60,000 RPM
- Margin spin testing shows spin clip stops opening below ~25,000 RPM
- Design Margin is 2.40:1

Air Gun Testing

Air gun testing performed on 5 fuzes

- Test designed to accelerate fuze to 100,000g's
- Spin clip and probe were tested to ensure shear failure would not occur during setback



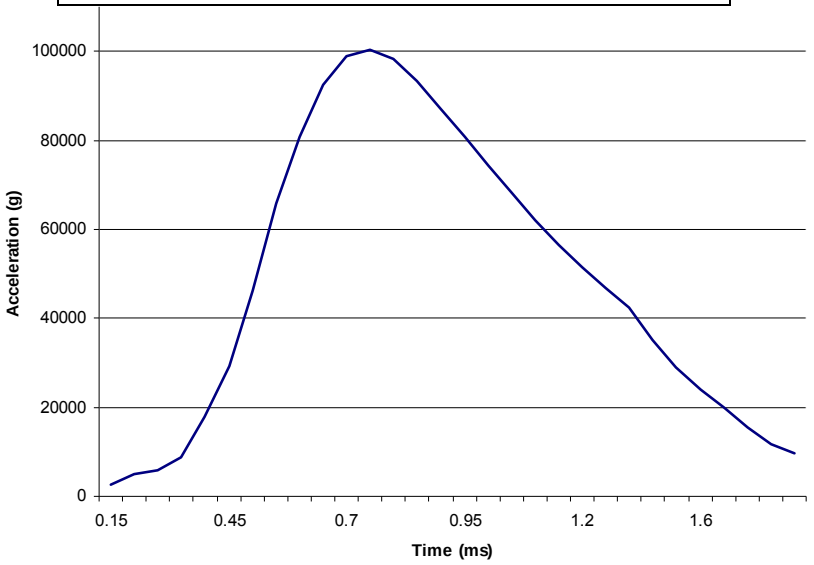


Air Gun Testing

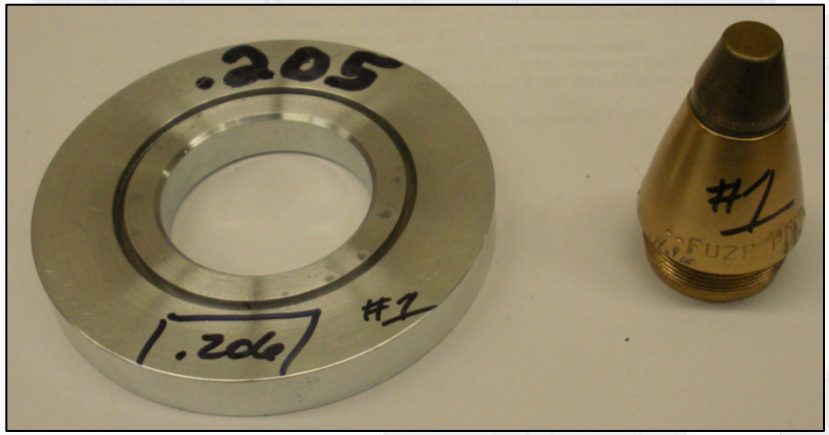
Air Gun Test Data

	Pressure	Acceleration
#1	16,800 psi	103,235g's
#2	16,871 psi	103,627g's
#3	16,910 psi	103,911g's
#4	17,020 psi	104,587g's
#5	16,820 psi	103,358g's

Actual Ballistic Data



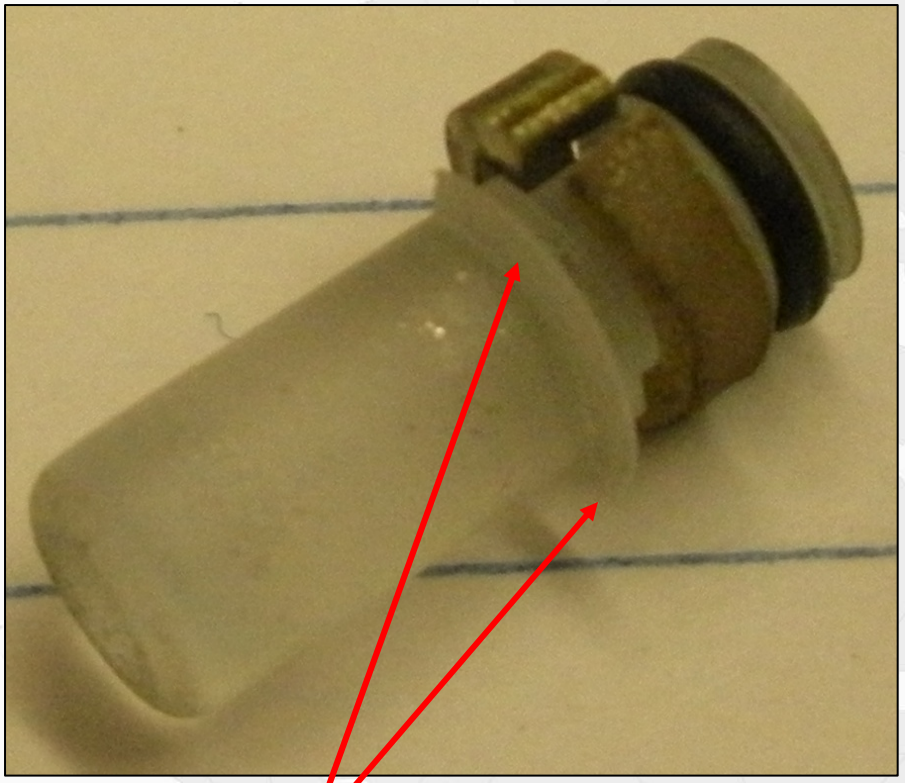


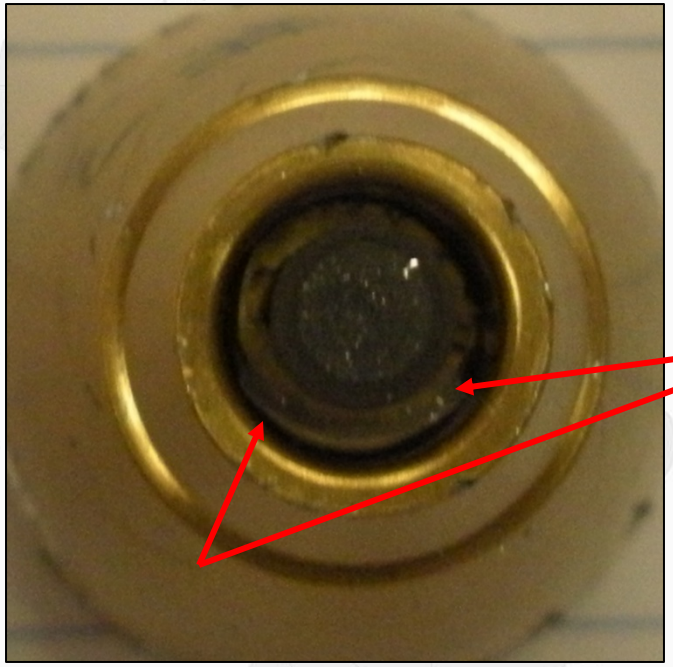


Air Gun Testing

Results

- Spin Clip survived 5 of 5 tests
- Improved Probe yielded under setback loads in all 5 tests



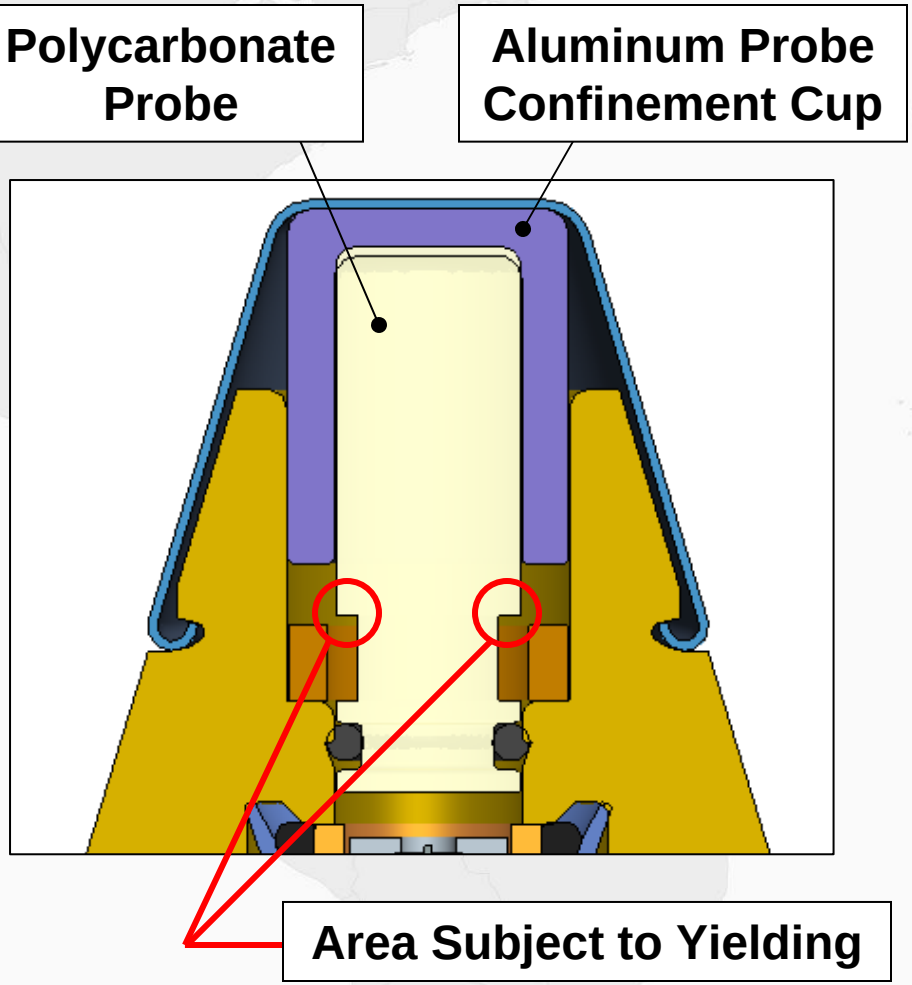


Probe Yielding

Design Refinement

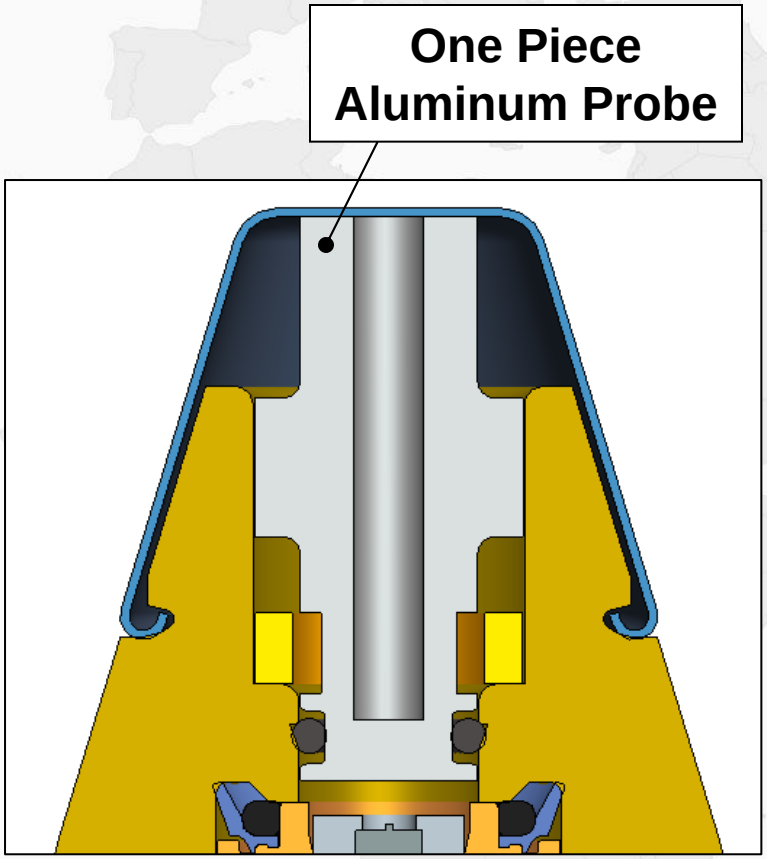
Improved Probe Design

Polycarbonate probe is subject to yielding at spin clip interface



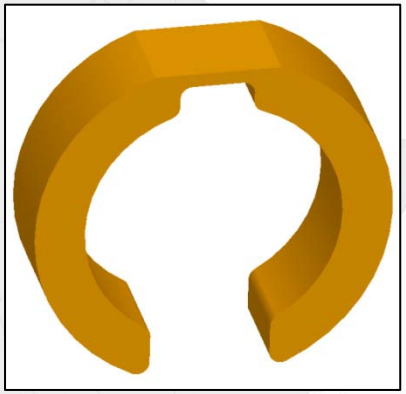
Refined Design

Aluminum probe resists yielding during setback



Design Refinement

- Improved probe design refined to survive setback loads
  - Material: Aluminum Alloy 7075-T735
  - Probe and probe confinement cup combined into single aluminum piece to reduce cost/complexity
- Spin clip design refined to aid in setback survival
  - Clip height reduced to provide more uniform “grip” on probe
- Probe & spin clip mass matches original probe & confinement cup mass
- Initial lab tests verified design improvements
  - Static tests show aluminum probes survive setback, 100,000g’s
  - Initial spin tests show spin clips open at 60,000 RPM





Air Gun Testing

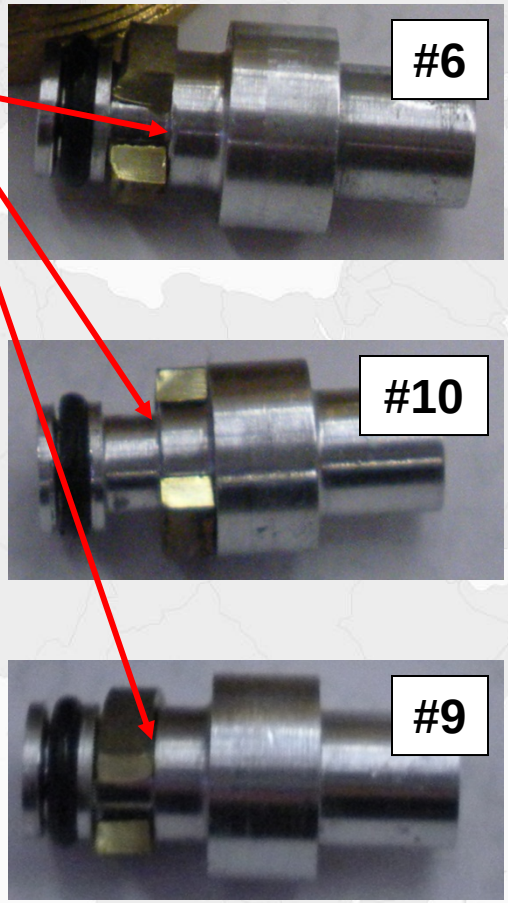
Tested Refined Design Under Setback Environment

Air Gun Test Data

	Pressure	Acceleration
#1	18,823 psi	115,712g's
#2	18,863 psi	115,937g's
#3	18,748 psi	115,370g's
#4	18,398 psi	113,339g's
#5	17,769 psi	109,270g's
#6	20,437 psi	125,439g's
#7	19,592 psi	120,377g's
#8	19,677 psi	120,831g's
#9	19,692 psi	120,944g's
#10	20,076 psi	123,292g's

No Evidence of Probe Yielding

25% margin over tactical environment



Refined Probe design survived **10 of 10** tests with up to a 25% margin, no probe yielding observed

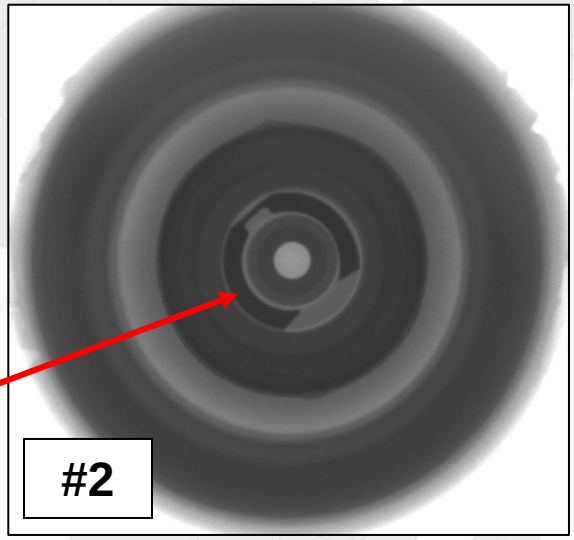
Spin Testing

Tested Refined Design Under Spin Environment

Spin Test Data

	RPM	Air gun Acceleration	Spin Clip Operation
#1	60,000	115,712g	Opened
#2	60,000	115,937g	Opened
#3	60,000	115,370g	Opened
#4	60,000	113,339g	Opened
#5	60,000	109,270g	Opened
#6	40,000	125,439g	Did Not Open
#7	46,000	120,377g	Did Not Open
#8	60,000	120,831g	Did Not Open
#9	60,000	120,944g	Did Not Open
#10	60,000	123,292g	Opened

Test data shows that spin clip opens at spin environment, 60,000 RPM.



Clip opened at 60,000 RPM after 115,937g's

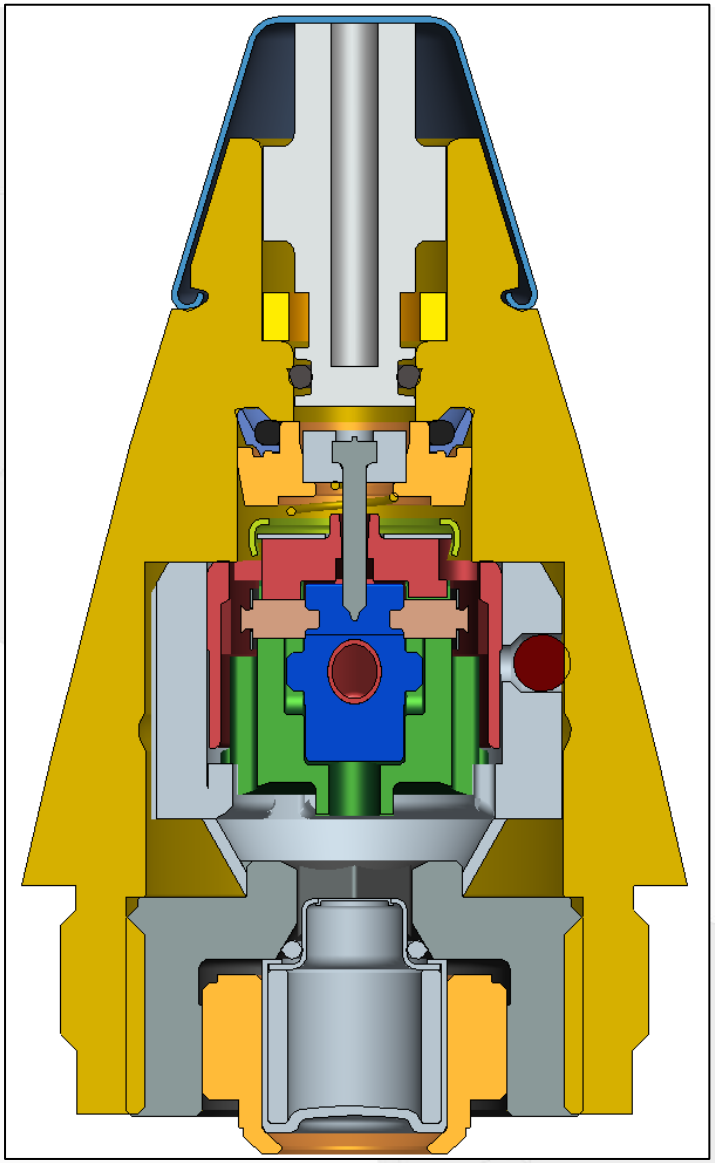
Testing Results

- Air gun tests performed on refined design
  - Probe yielding eliminated at g-levels up to 125,000g's
- Spin tests performed on air gun test fuzes
  - Fuzes accelerated to <116,000g's resulted in spin clips opening at 60,000 RPM
  - Fuzes accelerated to ≥120,000g's resulted in spin clips not opening at 60,000 RPM
  - More spin tests required to determine operational margin
- Lab testing shows a survival margin of up to 25%, and an operational margin of up to 16%

Planned Ballistic Testing

- Ballistic tests planned for 06/2009
- 100 improved rounds to be tested with 100 control rounds to compare detonation time
- Soft targets to be used at a range of 2000 meters
- High speed video to verify improvement over current design

Summary



- Modeling and simulation has predicted improvement in fuze sensitivity
- Lab testing has verified the operation of the fuze improvements at the tactical environment
- Ballistic rounds are being fabricated to test improvements over the current design
- The FTI improvements to the M579 fuze will provide the War Fighter with an HEDP round that is more effective against soft targets.



Wireless Programming of 40mm Grenade Launcher Ammunition

Christian Johnsen
Project Manager

Nammo

PRECISION PEOPLE TECHNOLOGY

Contents

- Introduction to Nammo
- Overview of Concept
- Integration to weapon systems
- Distribution of fragments
- Specifications
- Jamming
- Status of program
- RF Concept used on other calibers

PRECISION PEOPLE TECHNOLOGY

Nammo Raufoss AS

- The ammunition factory was established in 1896
- Nammo is located at various sites in Norway, Sweden, Finland, Germany, Switzerland and the US.
- The main office is at Raufoss in Norway
- Nammo has about 1800 employees and a turnover of approximately 3 Billion NOK



PRECISION PEOPLE TECHNOLOGY

Nammo

Nammo Test Center

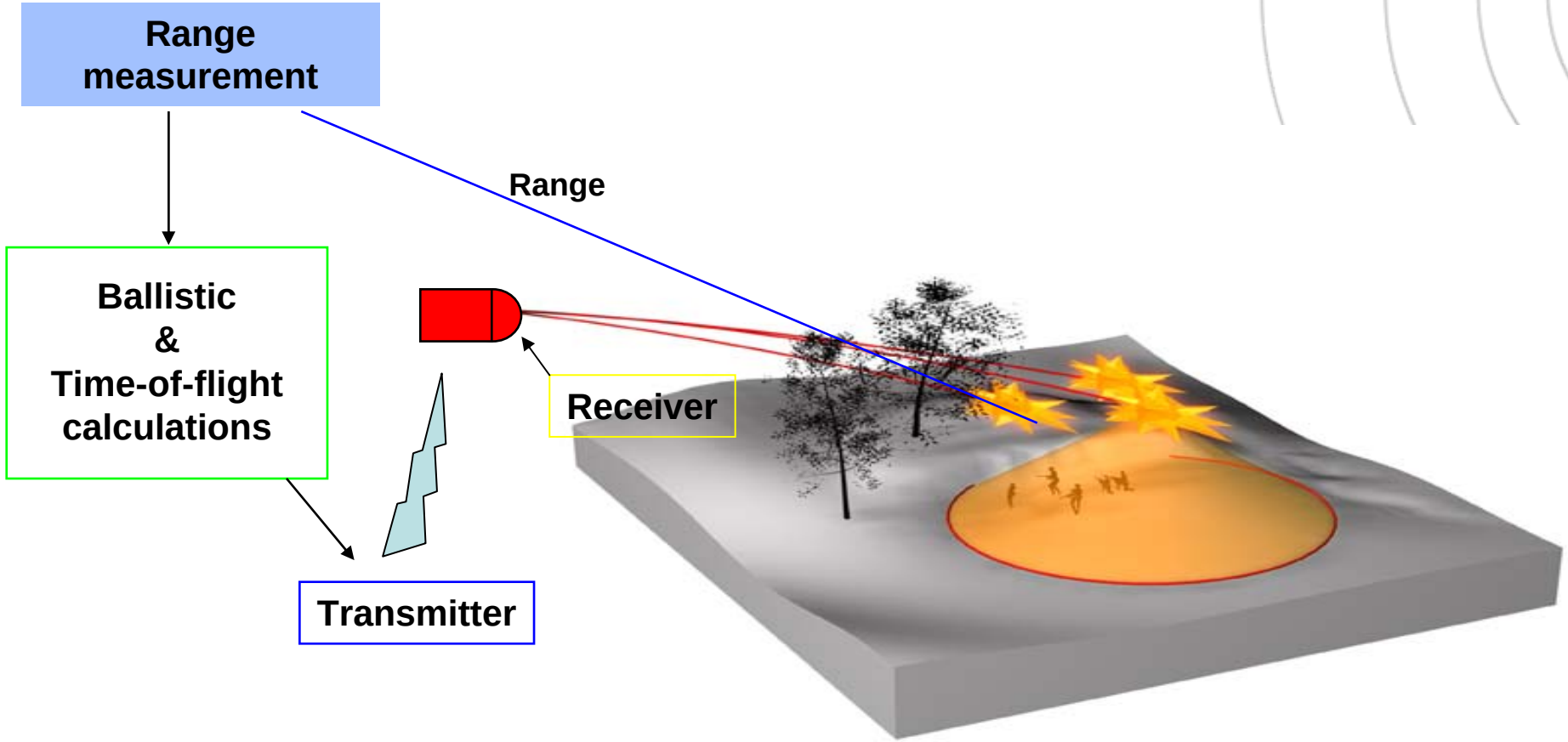
- Nammo has its own test center located 8 km from the main office at Raufoss
- 15 firing ranges from 0 to 2000 m
- Monorail for rocket firing
- Firing of 5.56mm to 155mm
- Environmental test center
- Example of test equipment
  - Radar
  - High speed video cameras
  - X-ray
  - Acceleration, shock and pressure



Nammo

PRECISION PEOPLE TECHNOLOGY

RF Air-Burst Ammunition Concept



PRECISION PEOPLE TECHNOLOGY

Nammo

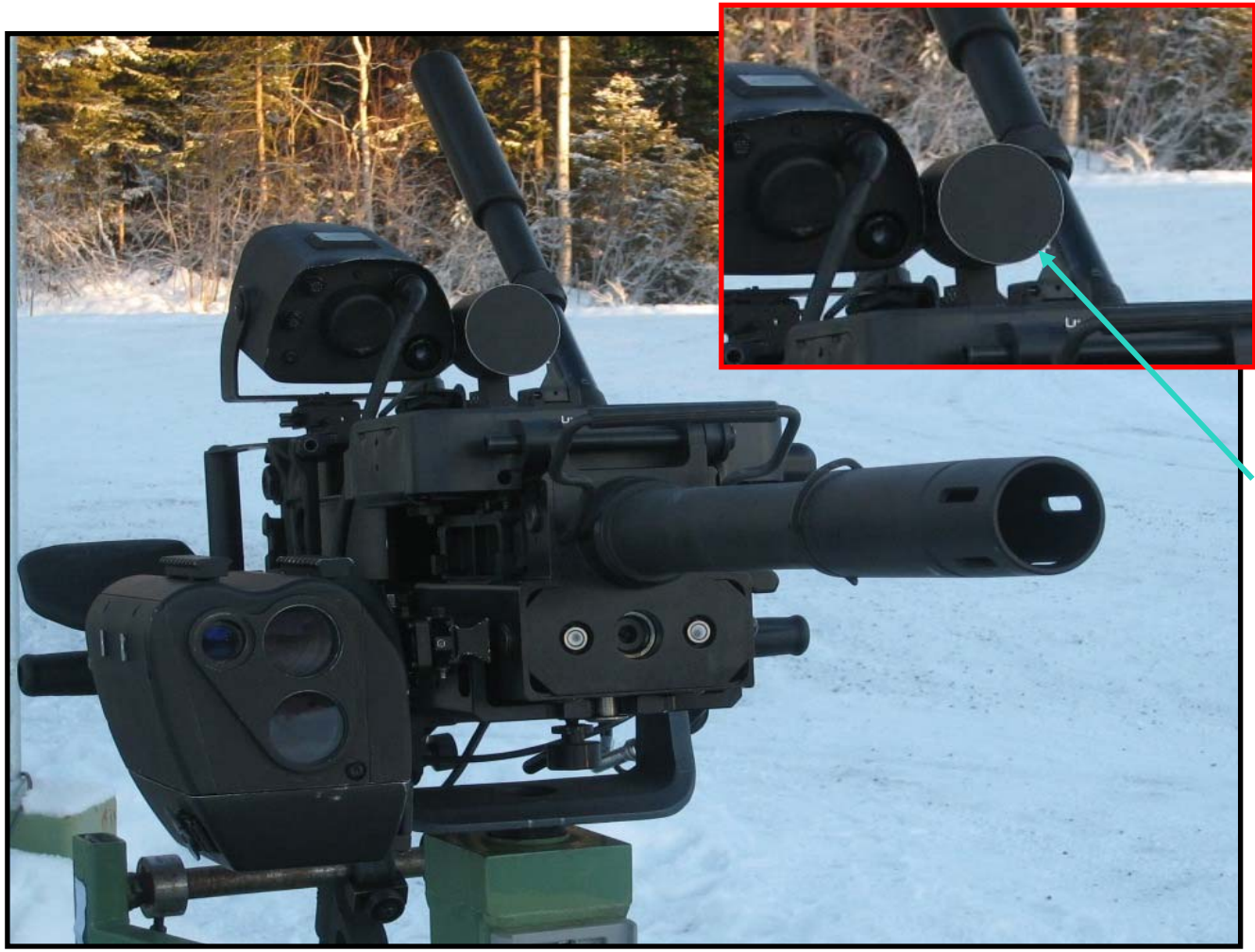
Easy integration to weapon systems

- Antenna unit
- Cable to Fire Control Unit
- Standard SPI or RS232 interface to Fire Control System
- **No modification of the weapon is needed**

PRECISION PEOPLE TECHNOLOGY

Nammo

H&K AGL with Vingmate Fire Control Units



PRECISION PEOPLE TECHNOLOGY

Nammo

H&K AGL with AIM Fire Control Units





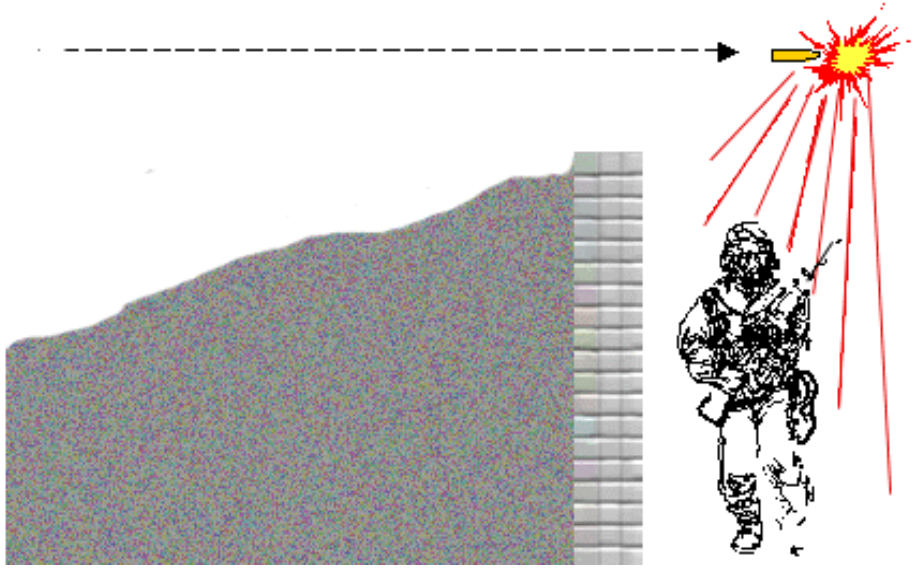
Antenna

Nammo

PRECISION PEOPLE TECHNOLOGY

Airburst Round, Highly effective in Urban Combat

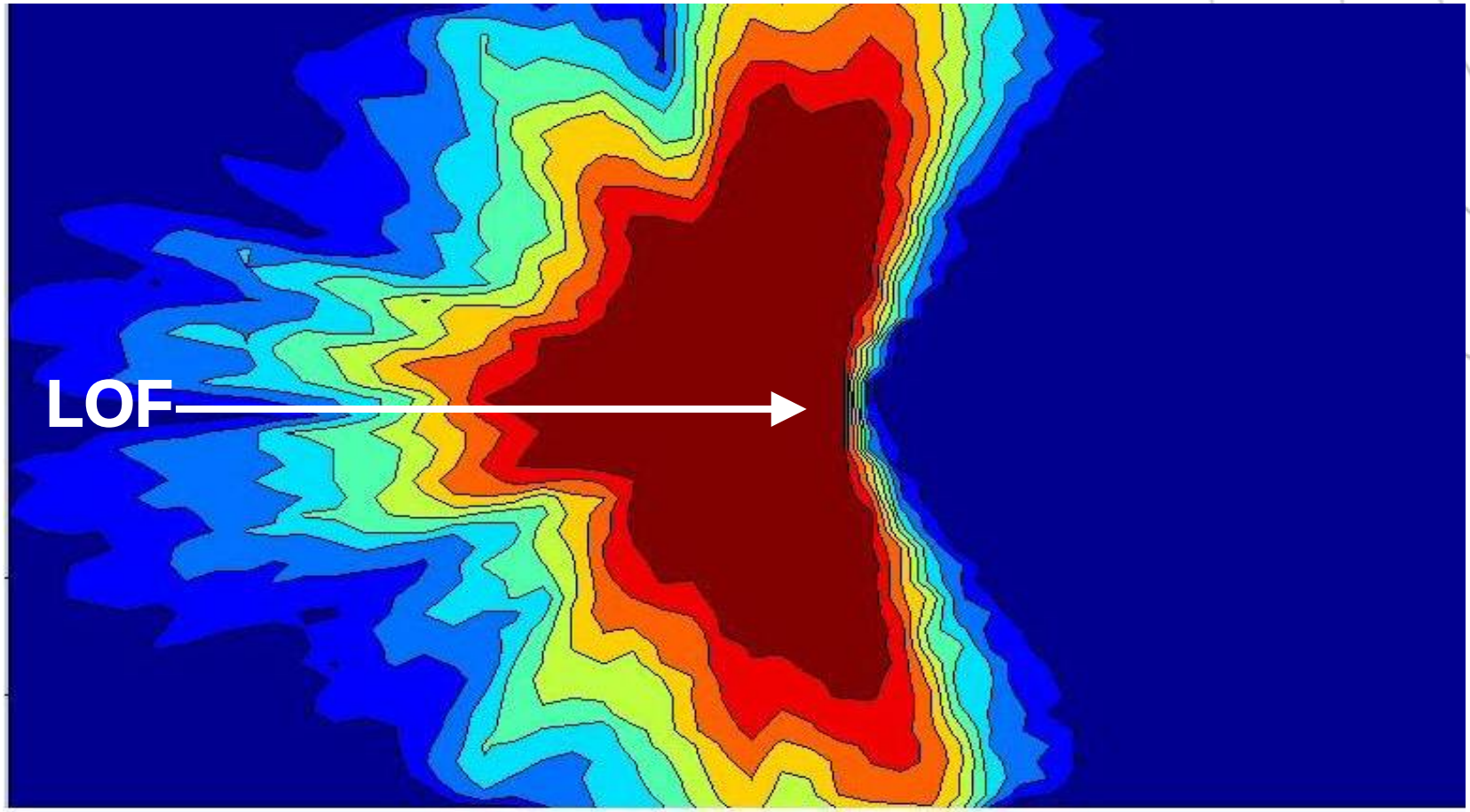
Takes out Targets in Defilade





PRECISION PEOPLE TECHNOLOGY

Incapacitation Contour



PRECISION PEOPLE TECHNOLOGY

Nammo

Specifications



- Electronic programmable Time Fuze
  - Airburst function (electronic)
  - Point detonating function (mechanical)
  - Self-Destruct function (electronic)
  - Mechanical Safe & Arm (US MK91)
- Pre-fragmented shell body
- IM Properties (use of PBXN 5 & 9)
- Improved Propulsion System

PRECISION PEOPLE TECHNOLOGY

Nammo

40RF grenade

Electronics

Loop Antenna

Safe & Arm Unit

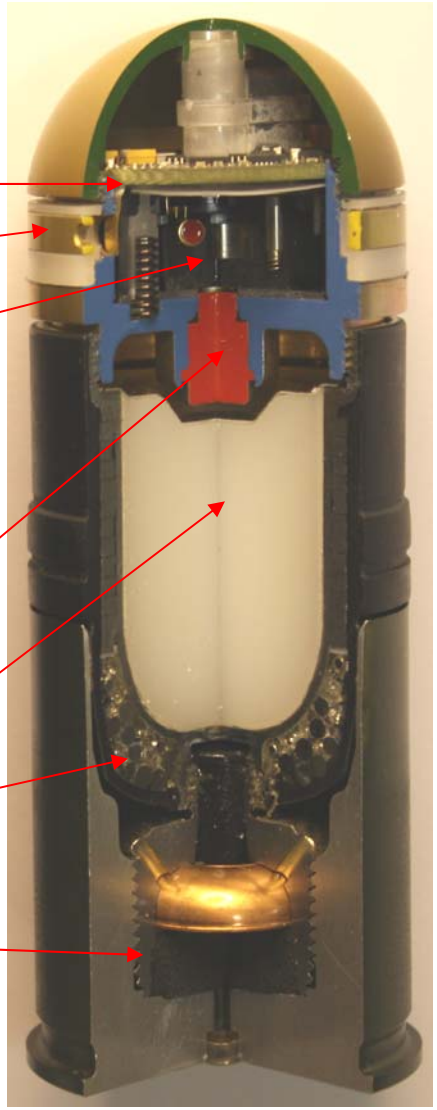
with electrical detonator

Booster (PBXN5)

Main Explosives (PBXN9)

Prefragmented body

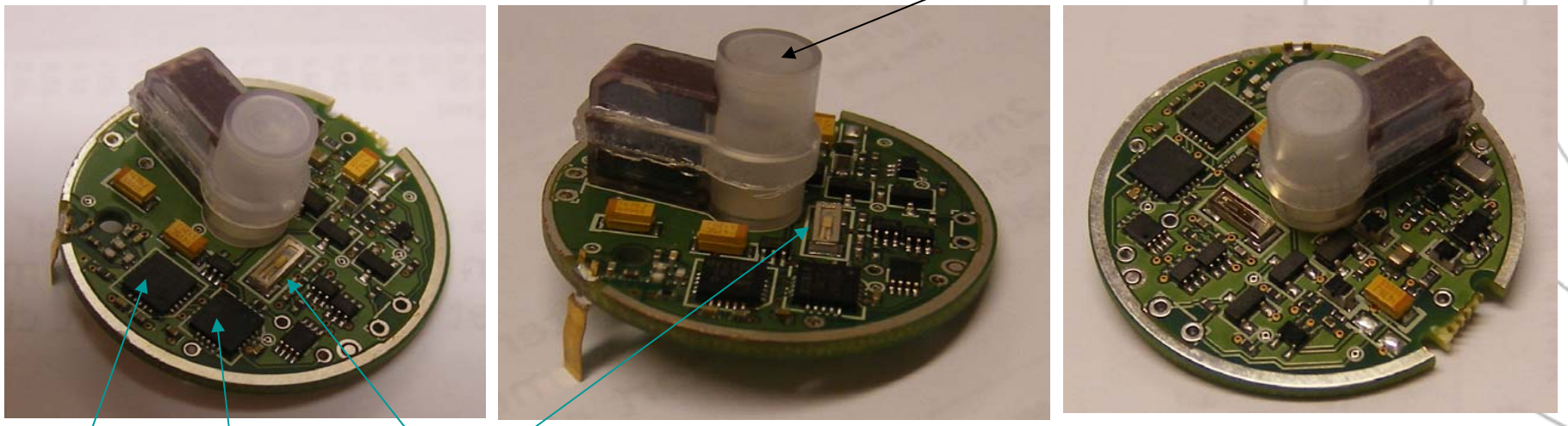
Propulsion system



PRECISION PEOPLE TECHNOLOGY

Nammo

Fuze electronics



-Airburst function

-Self destruct function ~20s (RC)

-Safe separation time ~430ms/100m (RC)



PRECISION PEOPLE TECHNOLOGY

Jamming

- Very narrow band transmission -> high effect in the actual band
- Distance from jammer to projectile >> distance from weapon to projectile
- Reprogramming the projectile not possible
- Frequency > 1 GHz in practice requires free sight
  - The jammer could be localized and taken out

PRECISION PEOPLE TECHNOLOGY

Nammo

Status

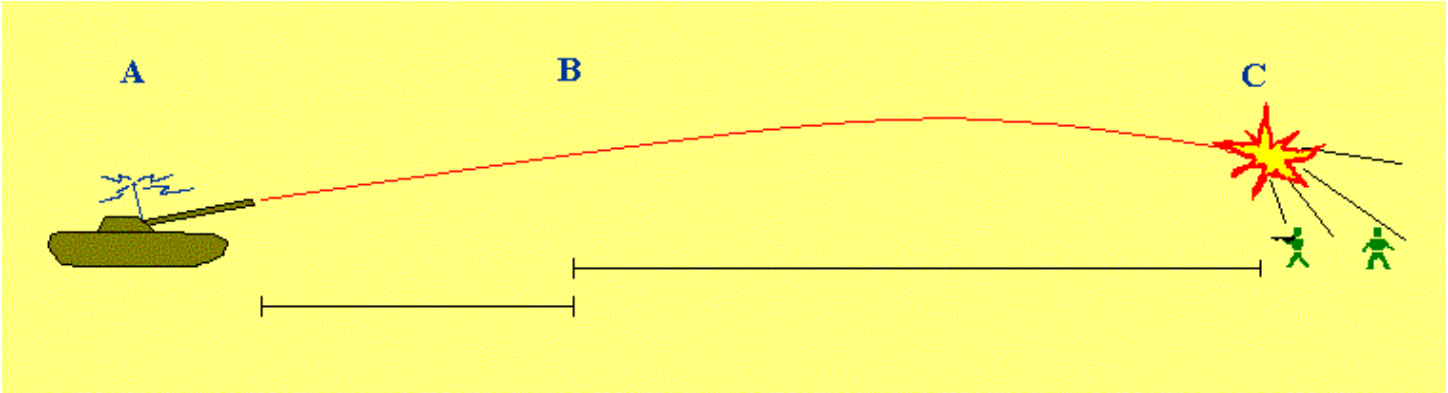
- In qualification
- Will be qualified this year (2009) for the H&K gun

PRECISION PEOPLE TECHNOLOGY

Nammo

Other calibers

- The RF concept can be used on other weapon platforms that need a Programmable Airburst capability



PRECISION PEOPLE TECHNOLOGY

Nammo



PRECISION PEOPLE TECHNOLOGY

Nammo

Pyro-MEMS
Technological breakthrough in fuze domain

Fuze Conference 2009

Renaud Lafont

Lake Buena Vista, FL

20th of May 2009

Approuved for public release

Content

1. NEXTER Munitions Fuze activities
2. Design & Demonstration of MEMS SAU
3. Design & Demonstration of 25mm Airburst ammunition Mk I
4. Design & Demonstration of 25mm Airburst ammunition Mk II

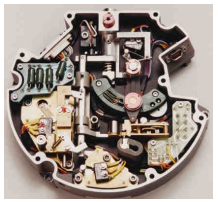
Approuved for public release

1. NEXTER Munitions Fuze activities

Approuved for public release

NMu: Fuzing System manufacturer

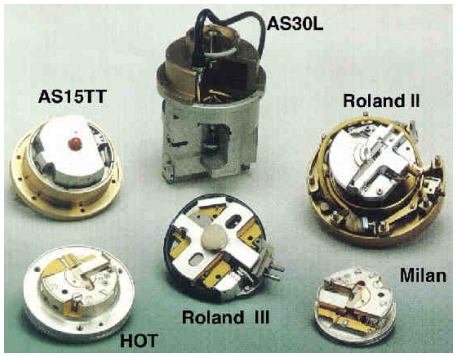
Products: Fuzing system & SAU for missile, tank ammunition (120, 100, 90 mm caliber), naval artillery (100mm caliber) and medium caliber (40, 30 and 25 mm caliber).

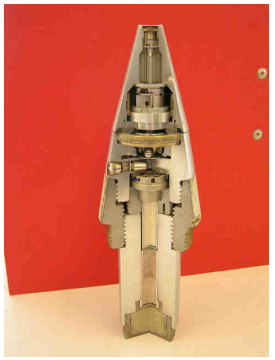




Strengthes:

- **Pyrotechnical components manufacturer (primary & secondary)**
- **Own proving ground**
- **The complete munition designer**



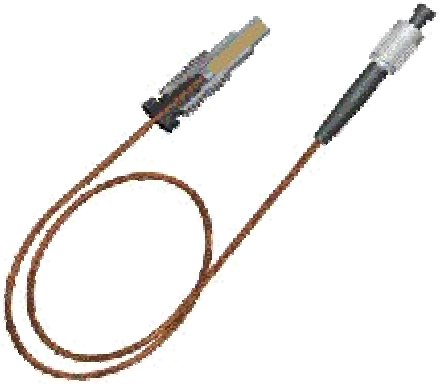


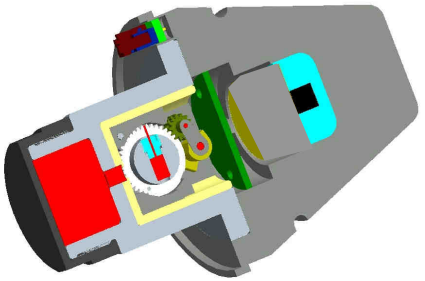
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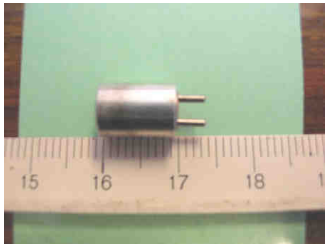
NMu: Fuzing System designer

Applications:

- Airbursting ammunition
- Opto-Pyro
- LEEFI
- ...







Strengthes:

- Modelisation
- Data recorder
- Own proving ground (static, pyrotechnics, dynamic)
- Same group than weapon system designer (NEXTER Systems)

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1) Design & Demonstration of MEMS SAU

Contract 03.04.078 – Demonstration of miniaturized SAU

Approuved for public release

1) MEMS SAU

Technology MEMS

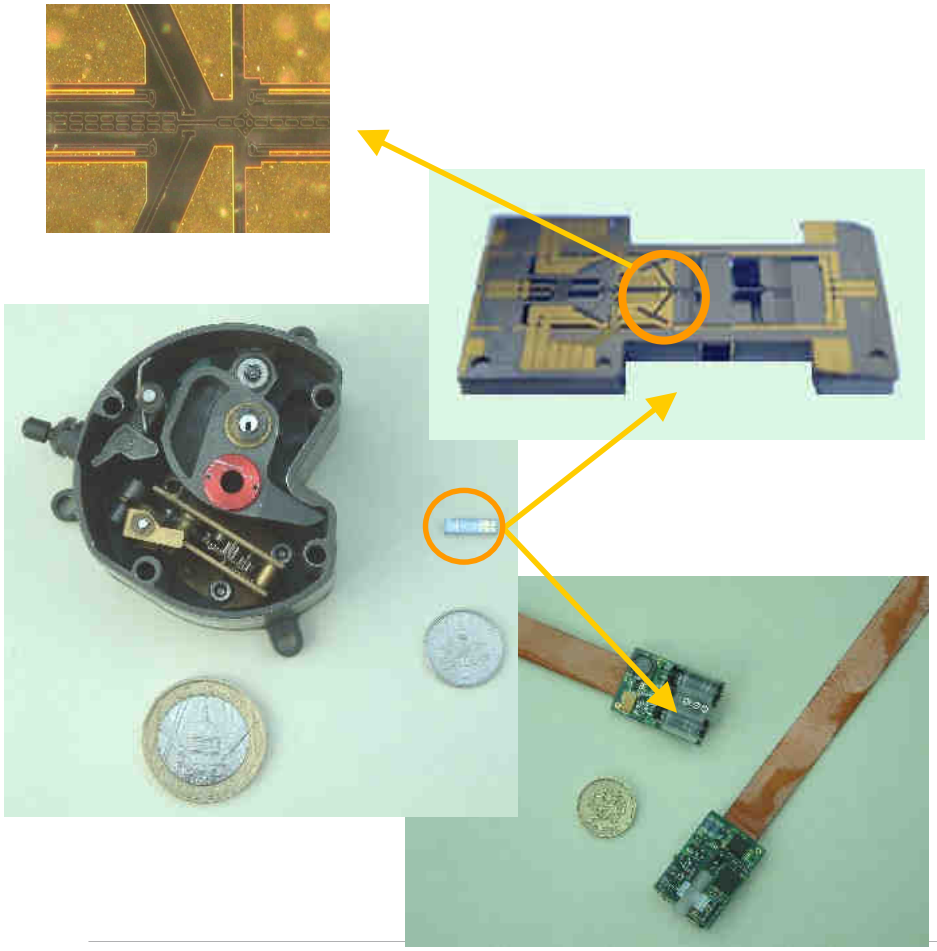
Pyrotechnical interruption

Miniaturized Electronic driver

STANAG 4187 compliance

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Micropyrotechnics, Synergy of mechanics, electronics & pyrotechni



The Step Forward

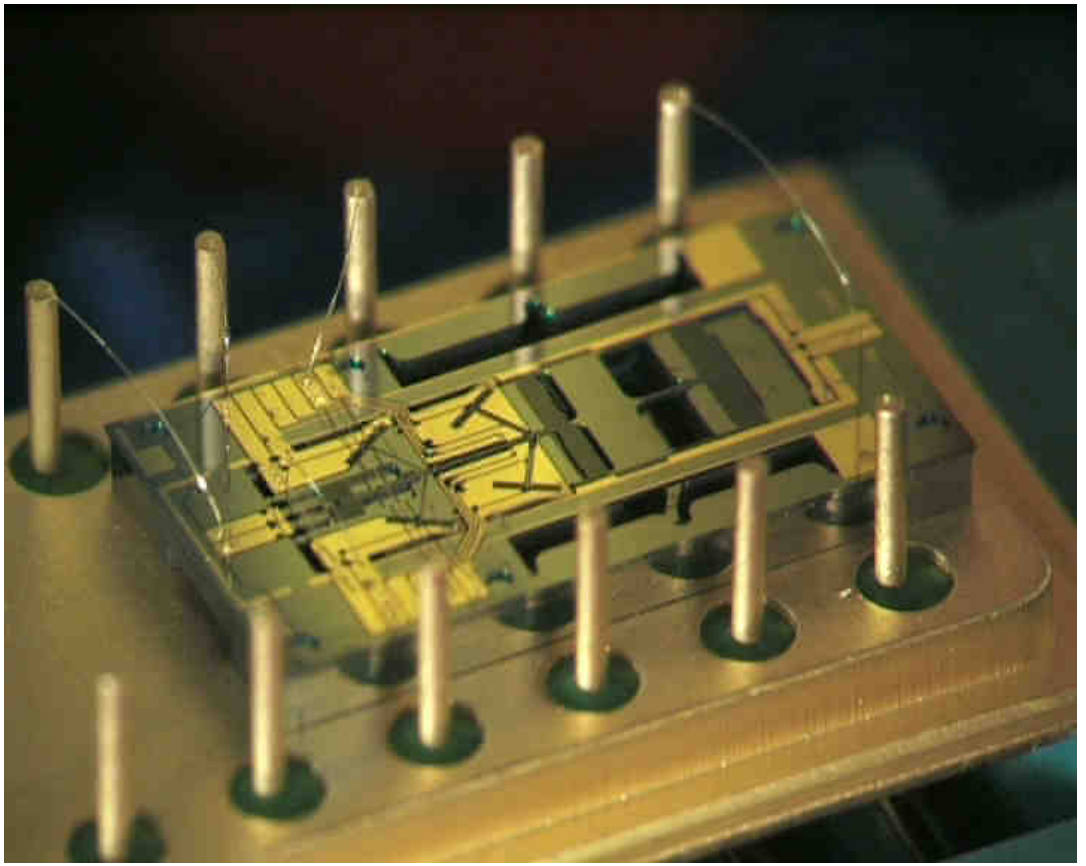
03/2007 – delivery of 10 µ-SAU

Requirement

- **Pyrotechnical safety managed by electronically controlled MEMS**
- **Volume less than 2 cm^3**
- **In accordance with STANAG 4187 (last edition)**
- **Ignition of EIDS**
- **Low cost**
- **Generic SAU**

Approuved for public release

Arming ability and reversibility



Approuved for public release

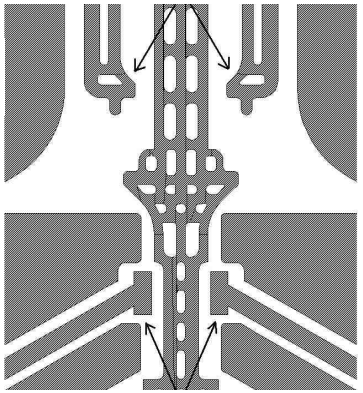
MEMS design according to STANAG 4187 requirements



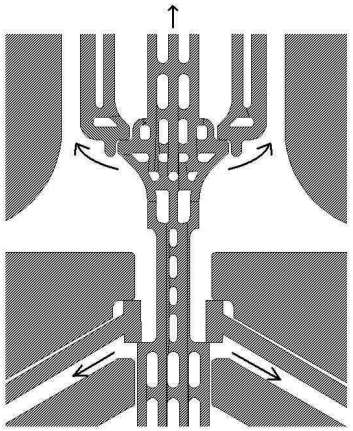
ARMED

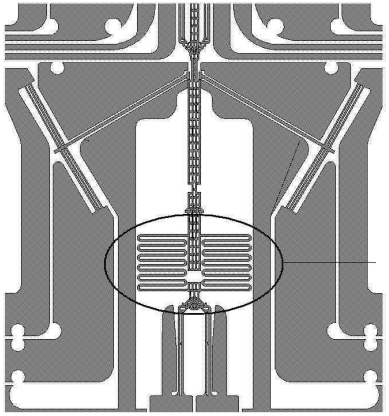
SAFE

1st Safety lock

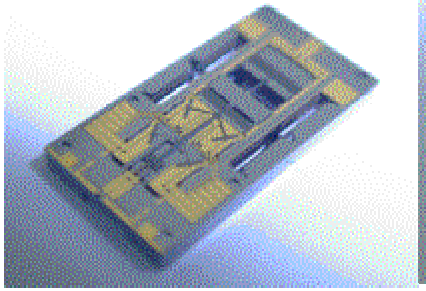


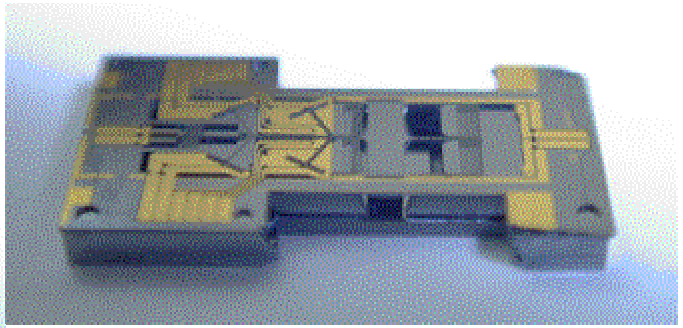
Arming displacement





2nd Safety lock

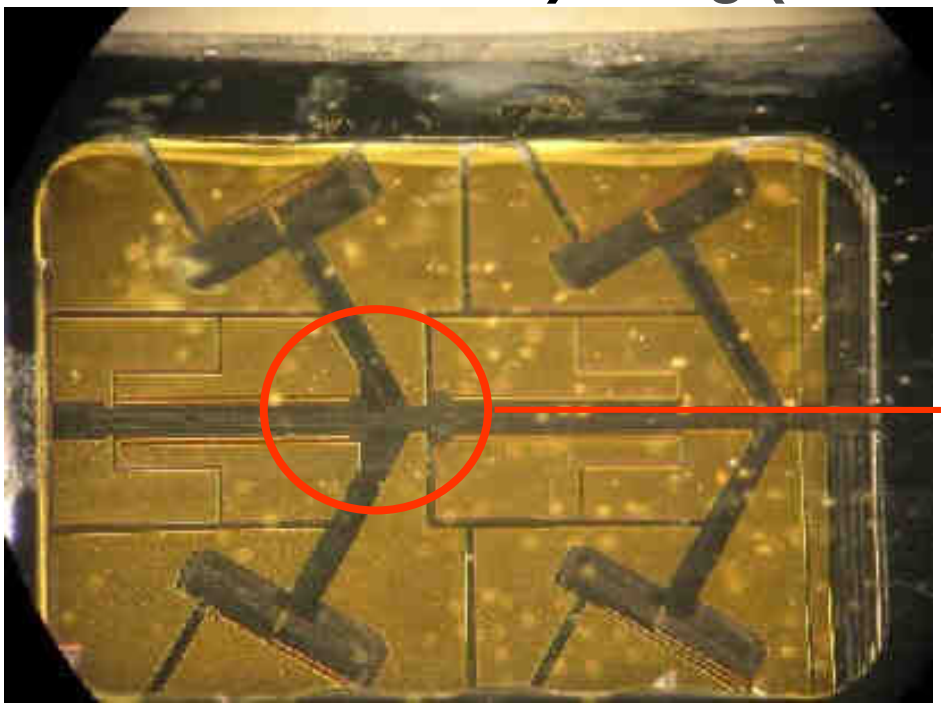


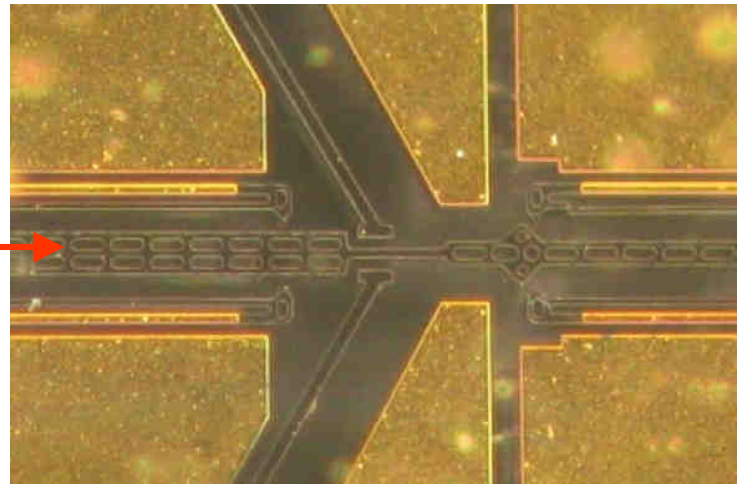


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Environnemental conditions :

- **120mm ammunition Polynege (Laser guided tank ammunition) firing (~10 000 g)**





View of the actuators after firing

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1) MEMS SAU

Technology MEMS

Pyrotechnical interruption

Miniaturized Electronic driver

STANAG 4187 compliance

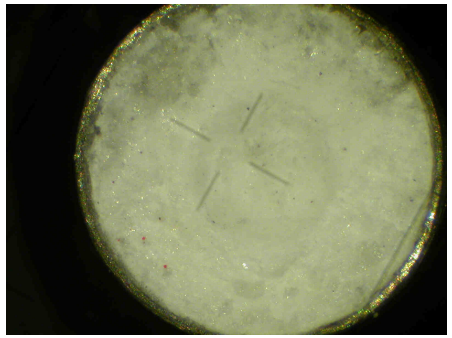
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Reliability and safety perfromances obtained by hardened tests (GTPS)

- **Reliability : 0,999 with 75 % confidence level**
- **Safety : 0,9999995 with 90 % confidence level**

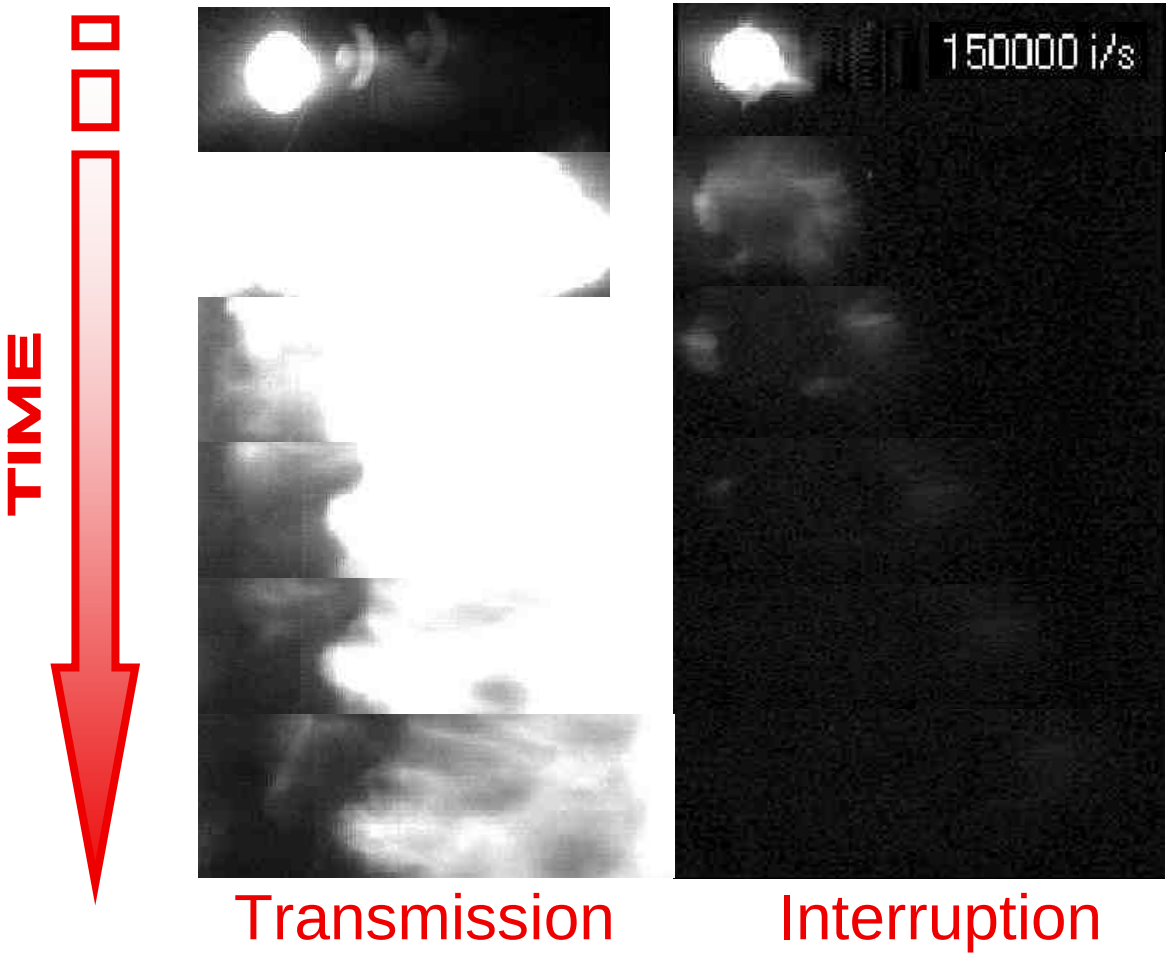


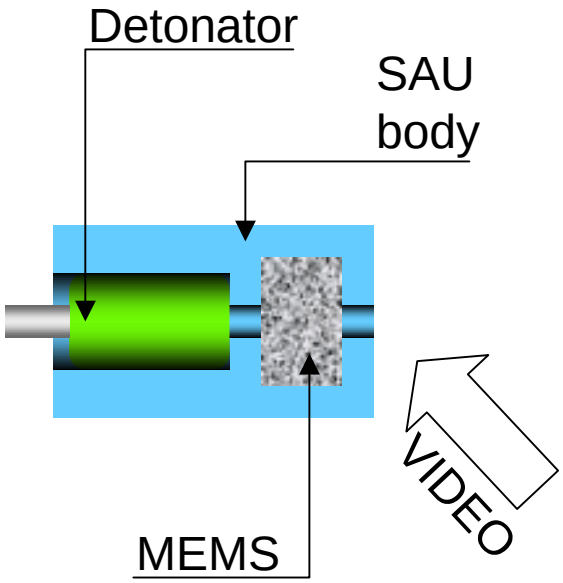
- **Interruption test on PETN booster**



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Pyrotechnical tests





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1) MEMS SAU

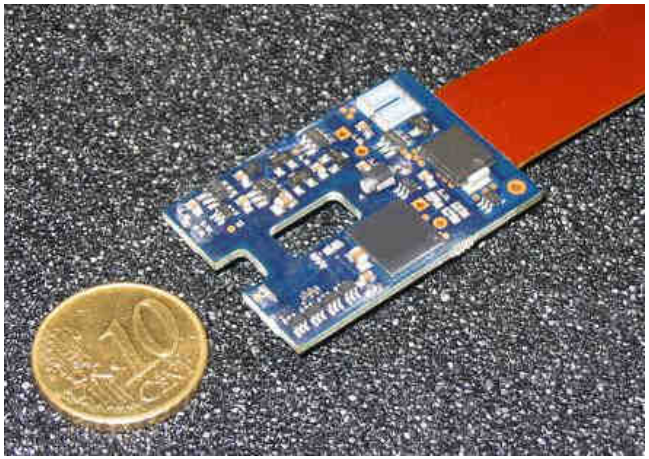
Technology MEMS

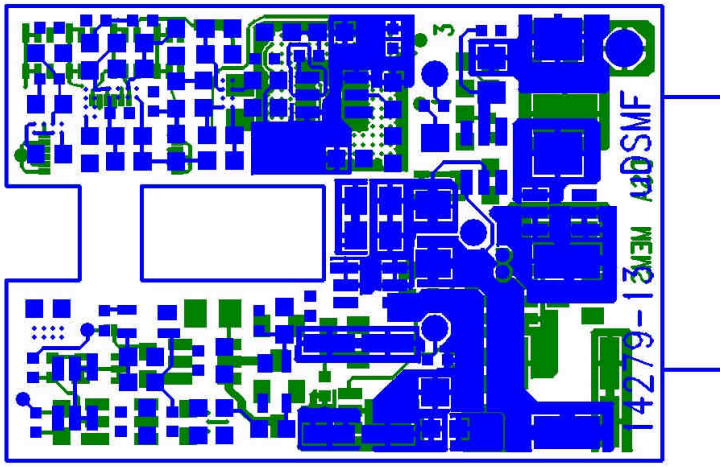
Pyrotechnical interruption

Miniaturized Electronic driver

STANAG 4187 compliance

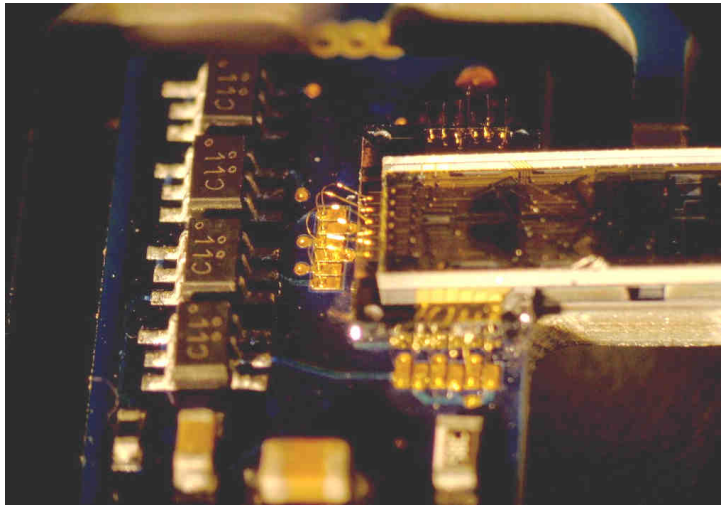
Approuved for public release





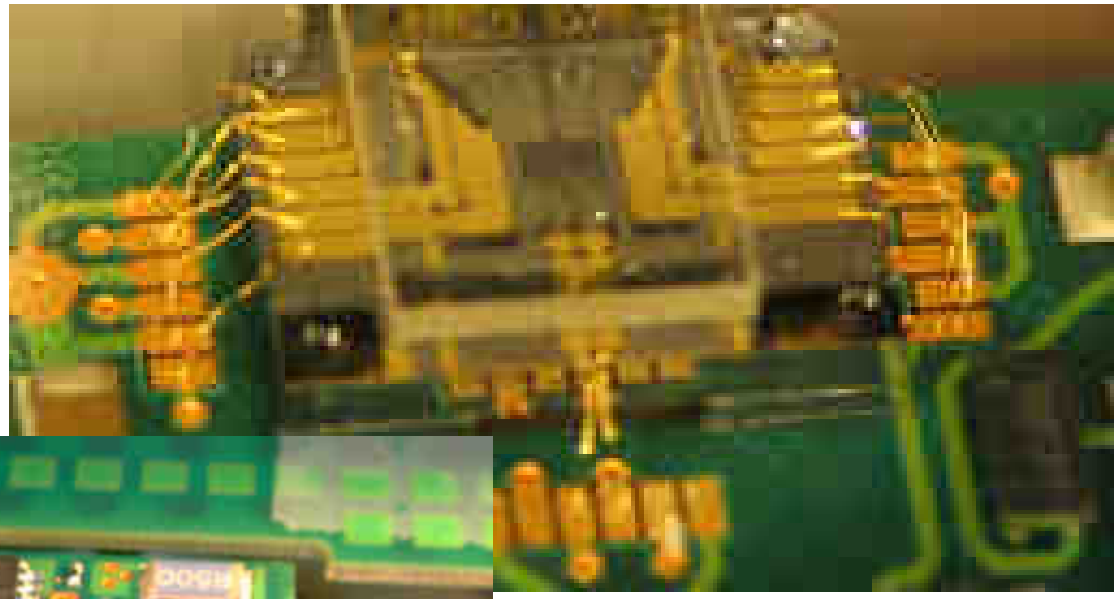
High density PCB

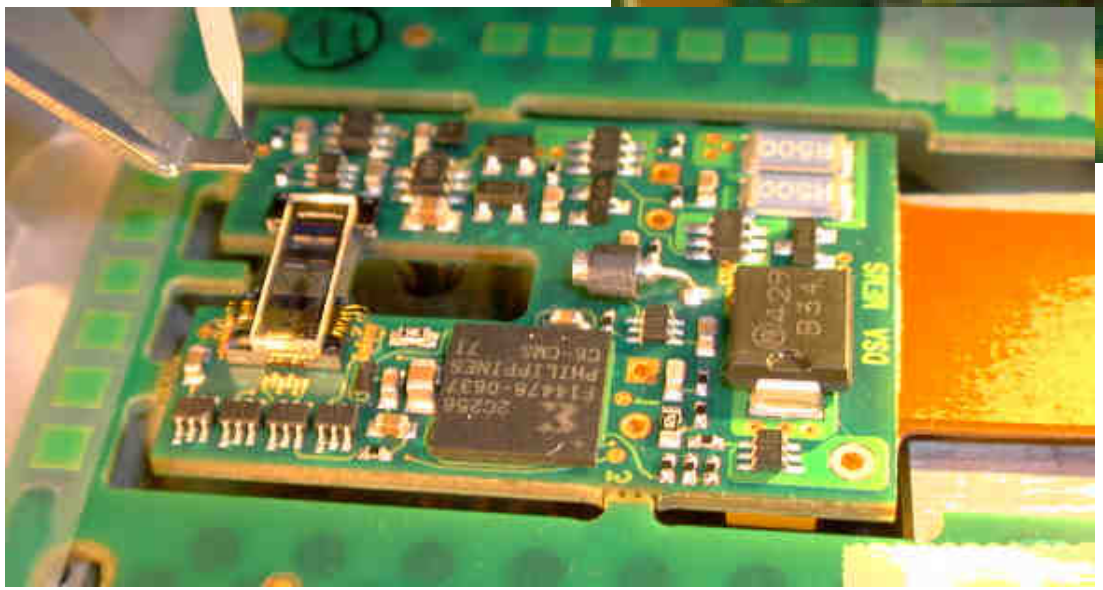
- **8 layers**
- **High density of parts**
- **« In Pad » vias**
- **In board vias**
- **« Flex » PCB**



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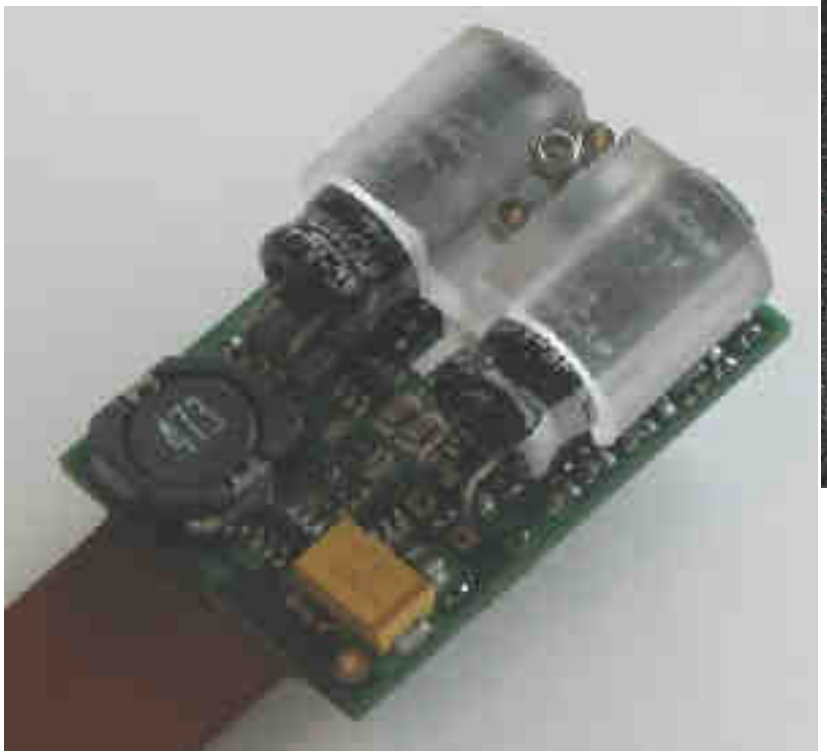
Integration

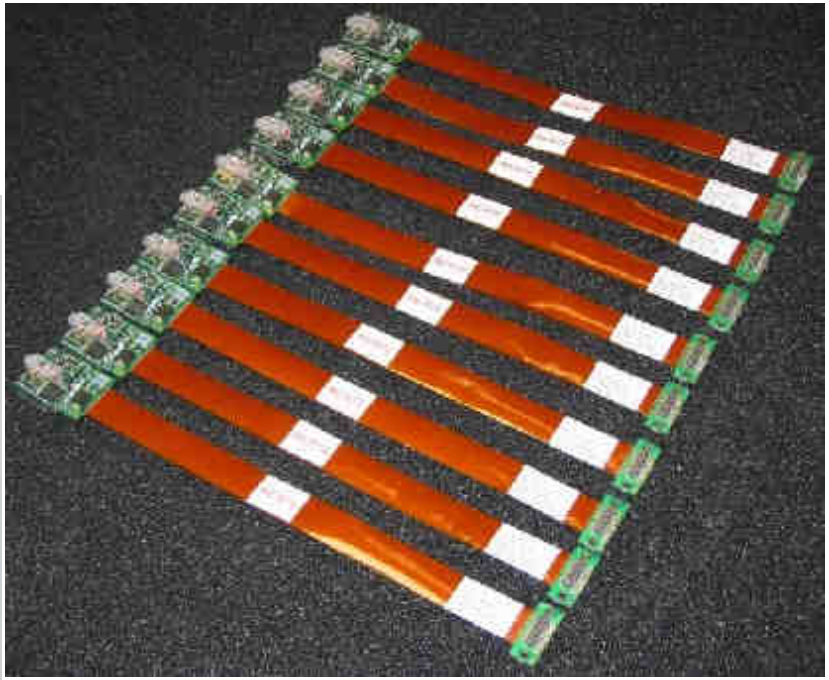




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Integration





Approuved for public release

1) MEMS SAU

Technology MEMS

Pyrotechnical interruption

Miniaturized Electronic driver

STANAG 4187 compliance

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Compliance with STANAG 4187

- ✓ **Two independant safety devices [Exg 6.a).1] : OK**
- ✓ **Two independant orders to authorize arming sequence [Exg 6.a).1] : OK**
- ✓ **Physical shutter between detonator and booster [Exg 8.a).1] : OK**
- ✓ **Explosive assessment and approval : COTS pyrotechnical devices OK [Exg 7.a)] : OK**
- ✓ **Efficiency of the interruption of the micro scale fire train : OK [Exg 8.a).2] : OK**
- ✓ **Non-armed guaranty during assembly and installation : [Exg 12.a)] : electrical information about shutter status is available**

Approuved for public release

1. Design & Demonstration of 25mm Airburst ammunition-Mk I

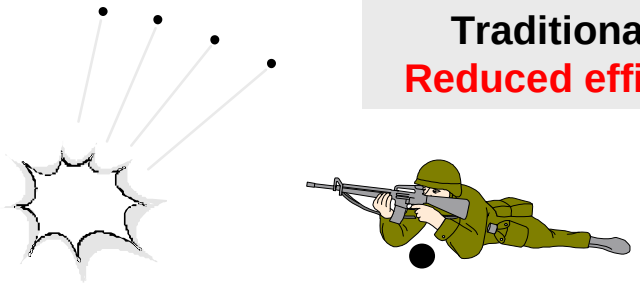
Contract n°05.50.208 – Improvements of medium calibre ammunition

Demonstrator for a programmable air bursting 25 mm round

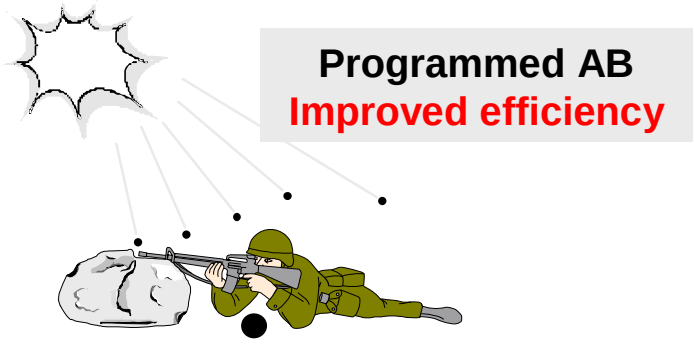
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Aims of the study

- Airburst has to be initiated above the target with an accuracy of 1 m at 1000 m
- Airburst mode shall be compliant with the maximal range of the 25, 30 and 40 mm weapons
- Impact mode available
- Compliance with STANAG 4187
- Airburst Fuze Programming Unit shall be able to equip existing weapons systems (retrofit)



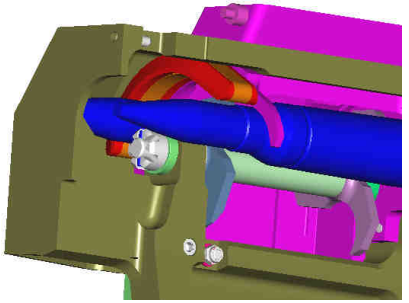
Traditional PD
Reduced efficiency



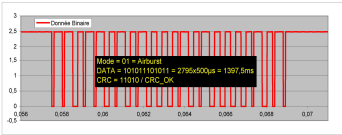
Programmed AB
Improved efficiency

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Mk I



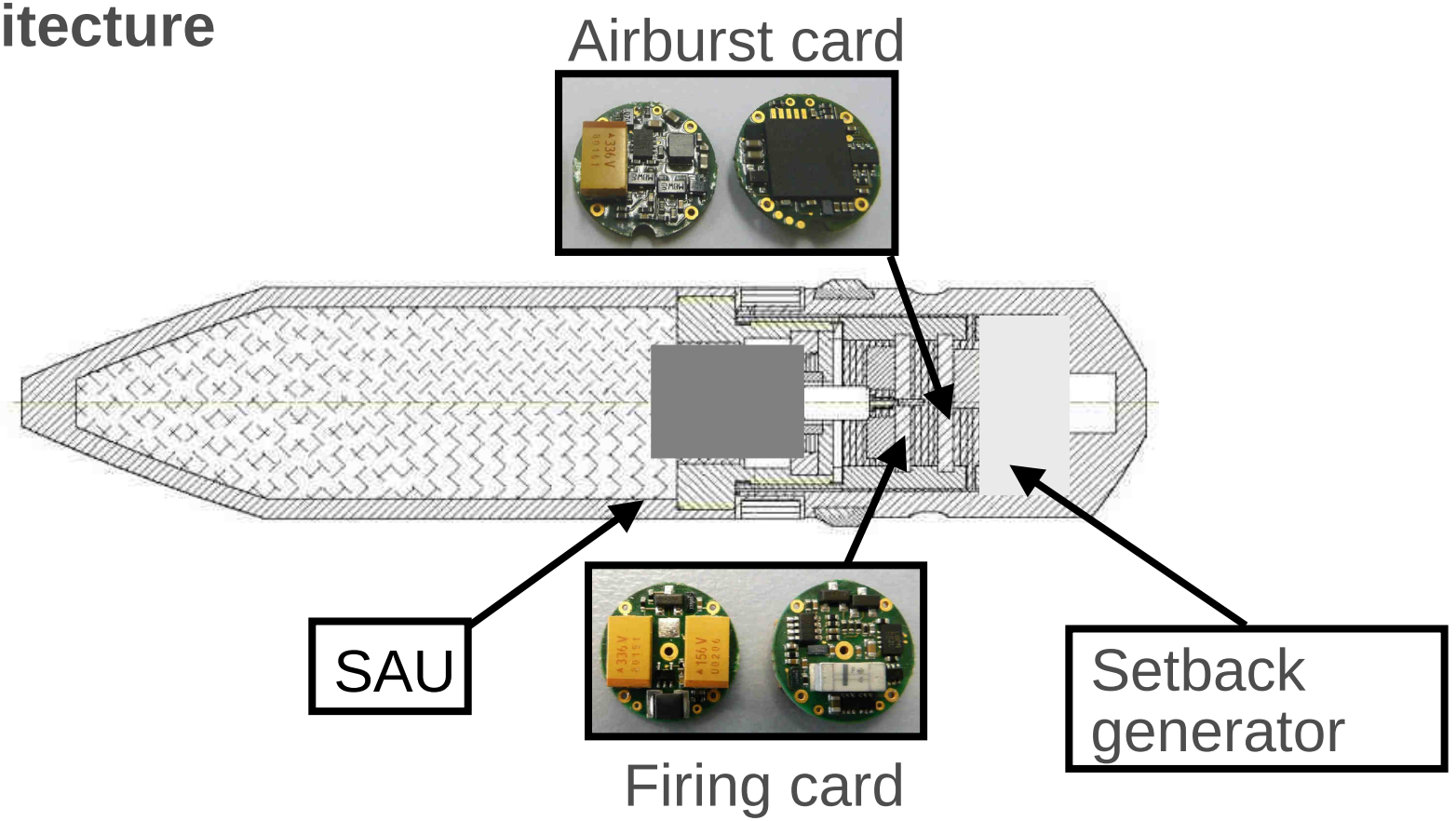
- **Programming Unit**
  - Inductive coil (Mode + Chronometry)
  - Impact mode remains available without programming unit
- **Operational modes**
  - Airburst +PD +Self-destruct
- **Airburst performances**
  - Chronometry : **+/- 50 cm** at 1000 m
- **Environment conditions :**
  - Medium calibre 25x137 : 100 000 g 1000rd/s





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► Architecture

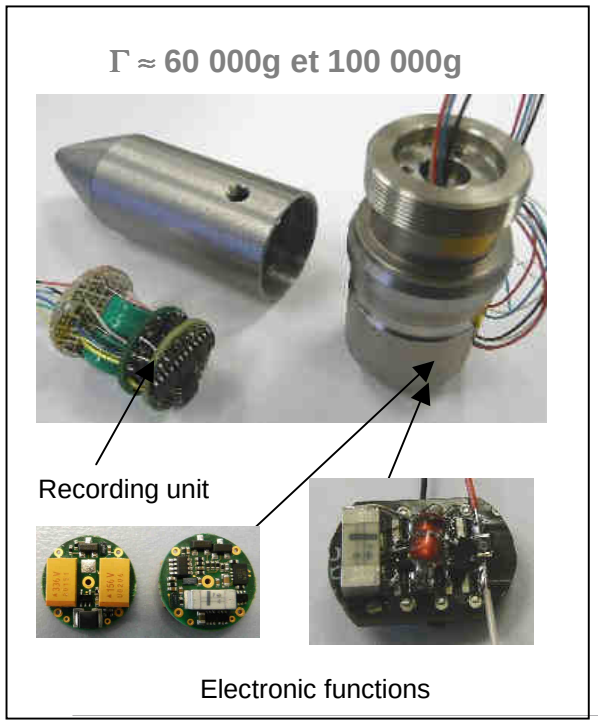


Electronics and SAU designs are deeply fit into each other during engineering process.

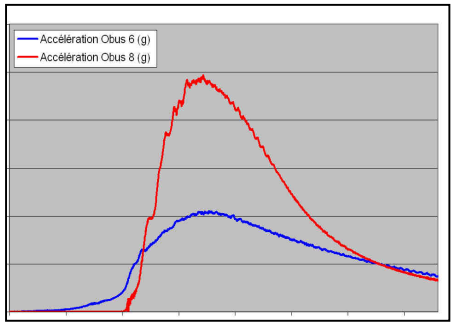
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Recorded flight tests

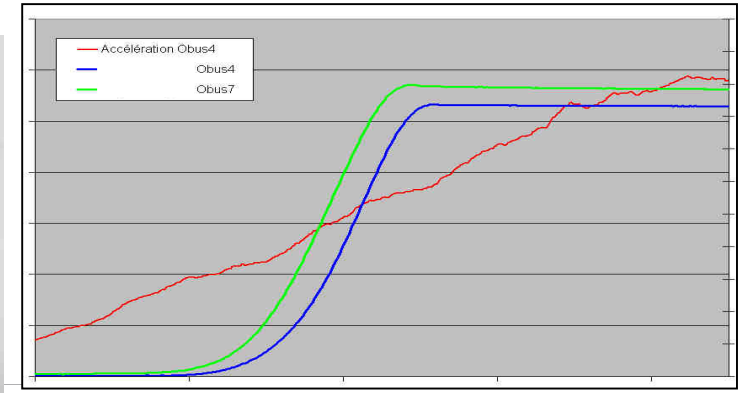
- Accumulated energy is generated by setback acceleration
- Chronometric accuracy assessment
- Detonator firing sequence









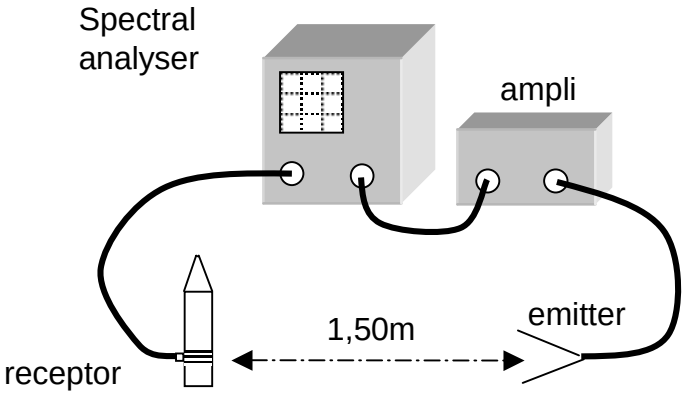


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EMC immunity assessment

Measures from 2 GHz to 18 GHz







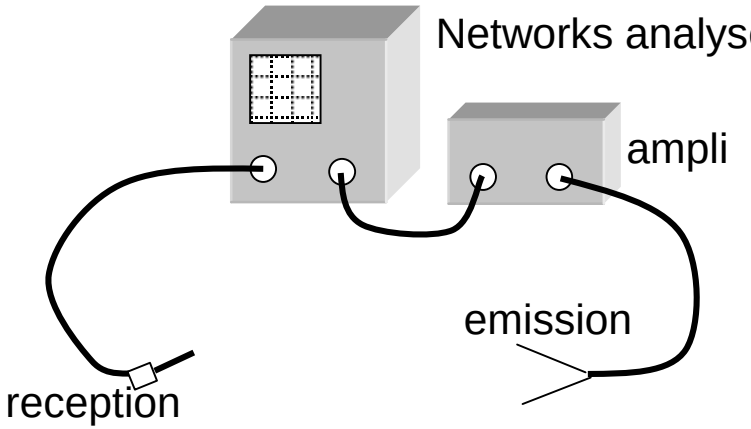
Induced voltage within the round coil is deduced by analysis from measures achieved thanks to vectorized spectral analyser



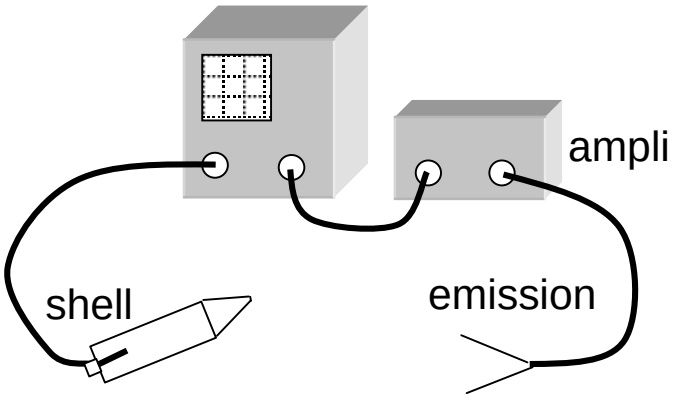
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EMR hazards immunity

Measures from 60 MHz to 18 GHz



STEP 1 : measure of max. level without ammunition



STEP 2 : measure of max. level within ammunition

- **Measures permits to assess the shell faradisation**
- **Analysis permits to evaluate the existing safety margins against EMR aggressions**



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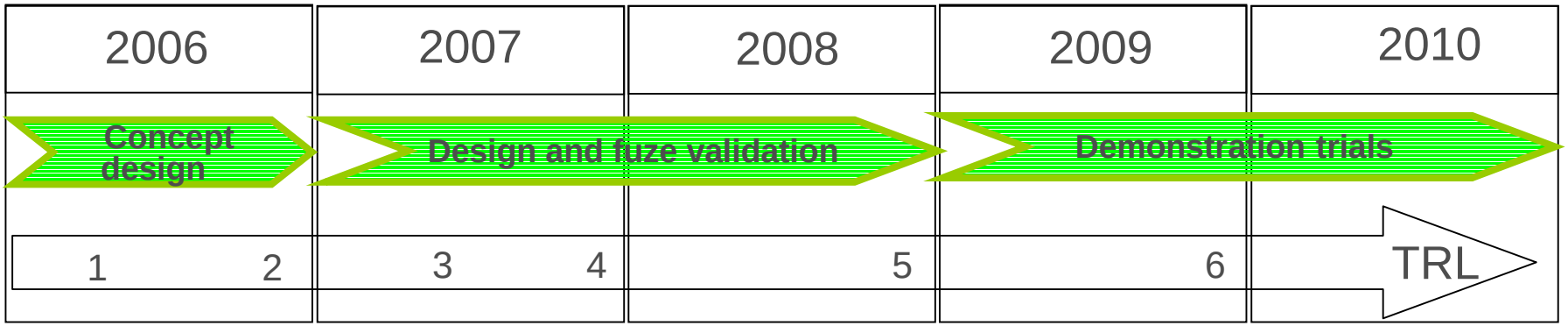
Demonstration NEXTER Munitions
French MOD – September 08



Approuved for public release

Fuze technology – MATURITY LEVELS

Sub-systems or Components	Main Techniques or Technologies Involved	Current TRL
25 mm airburst fuze	Electronics	6



. Conclusion

- **The maturity levels have grown quickly till today**
- **This growth is partially due to the new experimental techniques like in-flight data recorder at high level of acceleration**
- **2009 – 2010 will be the time for the demonstrations tests !**

Approuved for public release

1. Design & Demonstration of 25mm Airburst ammunition-Mk II

Self-funded study

Approuved for public release

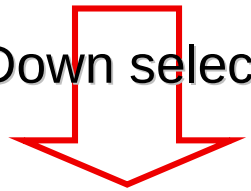
Synthesis

- Merge both programs (airburst and µSAU)
- µSAU advantages
  - **MEMS technology particularly adapted to Medium caliber ammunition: size & number of ammunition to produce**
  - **Cheaper: electronics industry**
  - **More reliable**
  - **Robust**
  - **Settable for the complete range of medium caliber**

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Self funded-study

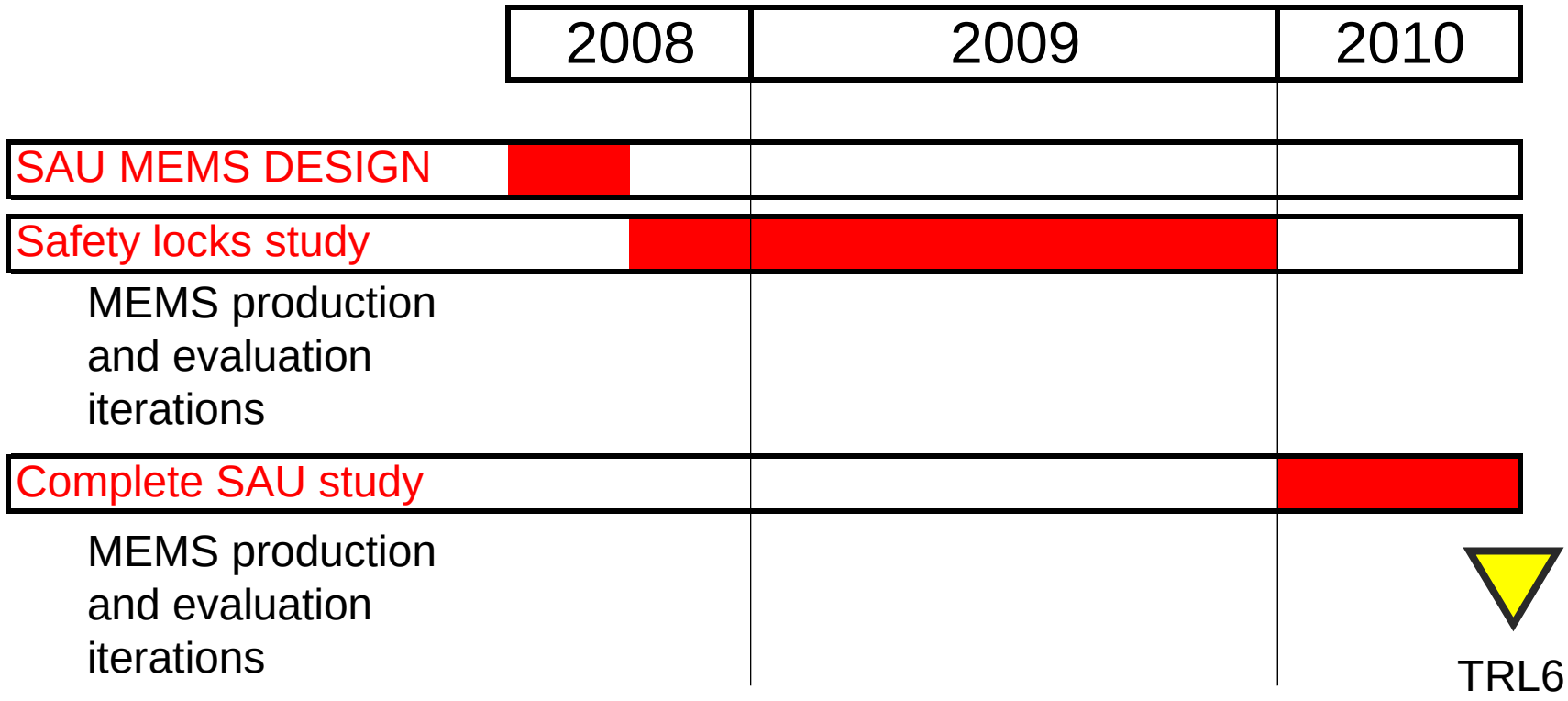
- µSAU design based on NMu pyro-MEMS experience
- Study of safety locks reacting straighthly to the arming environments
- MEMS SAU designed for electrical ou mechanical detonators
- Workflow
  - **Simulation, static and dynamic tests on each devices (setback & rotation safety lock, motion of the shutter**



  - **Simulation, static and dynamic tests for the complete MEMS SAU**

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Time schedule

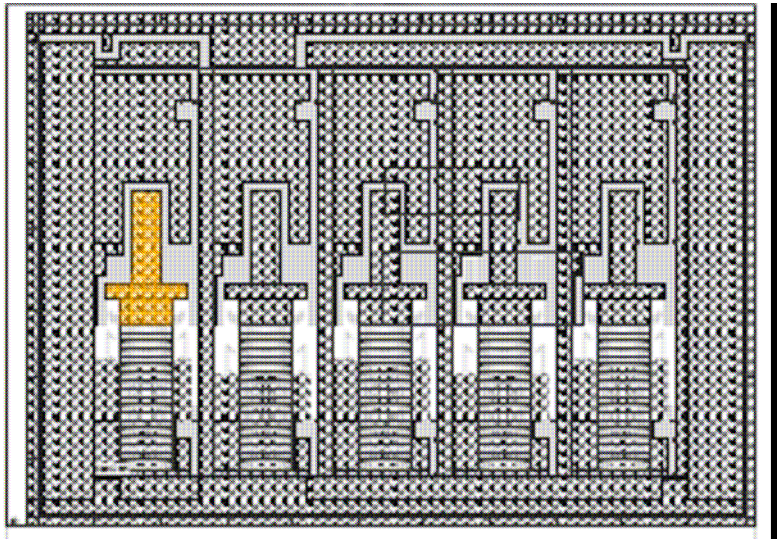


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Work in progress

- MEMS SAU design done (patended)
- First batch of MEMS produced
- First batch of MEMS tested
  - Structure able to withstand 100.000g
  - Safety locks operate





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Thanks to your attention

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A STRAIN GAGE BASED PROJECTILE HEALTH MONITOR AND SALVAGE INDICATING CIRCUIT FOR KINETIC ENERGY PENETRATING PROJECTILES

20 May 09

APPLIED RESEARCH ASSOCIATES, INC.
An Employee-Owned Company

Program Overview

- ***Develop a Means & Method to:***
  - ***Detect and Monitor Stresses Caused by:***
    - ***Weapon Case Axial Loads***
    - ***Weapon Case Lateral Loads***
  - ***Distinguish Between Normal and Deleterious Stress Conditions and Detect Excessive Kinematic Behavior***
- ***Verify the Method Against Real World Events***
- ***Design the Damage Signaling Circuitry`***

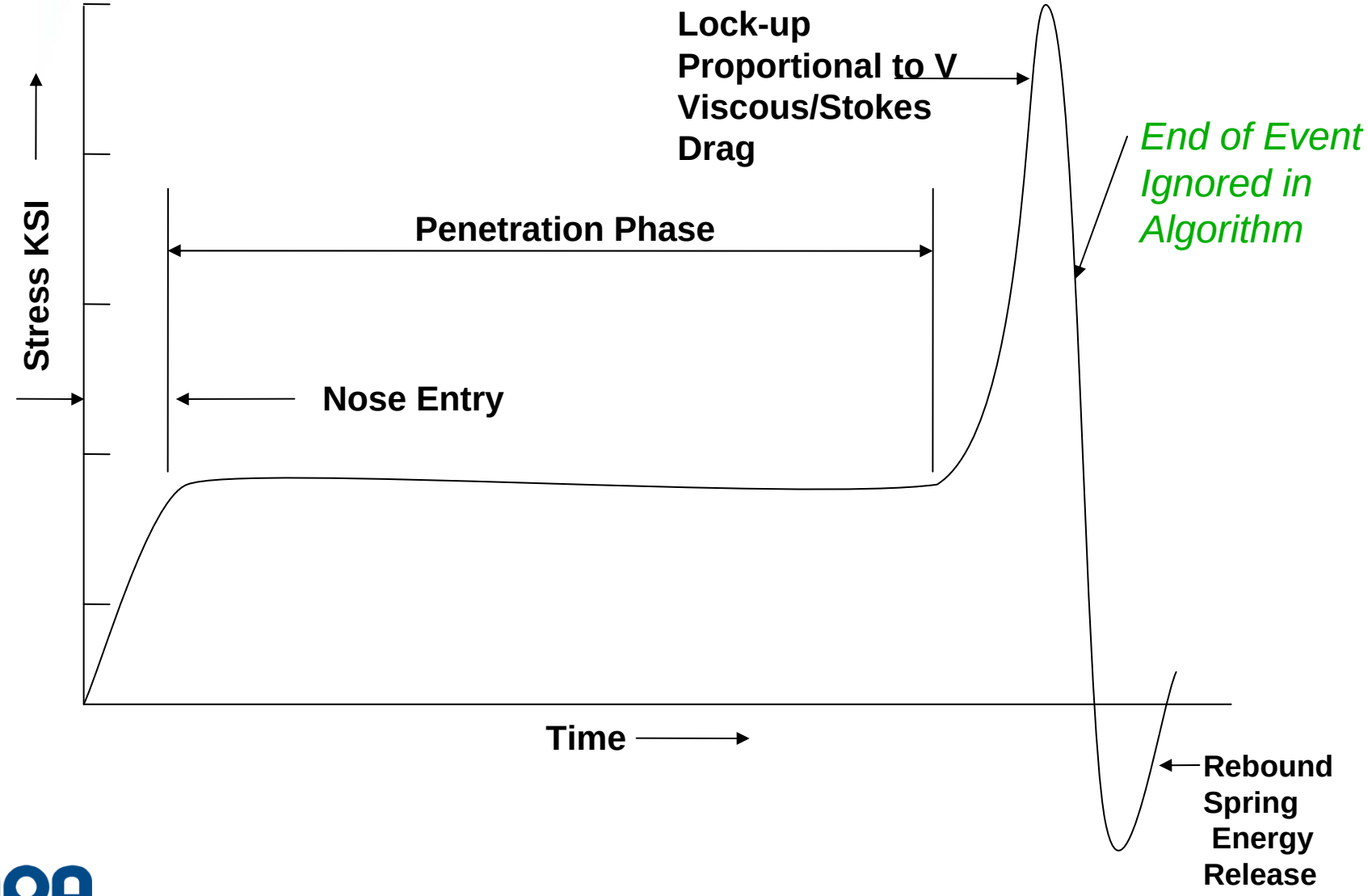
Program Goals

- ***Set-up the Detection Algorithm in a Simulator***
- ***Verify the Algorithm (method) against Real World Events (actual tests)***
- ***Design the Circuitry and Select the Transducer***
- ***Select the Hardware Interface for DSP Chip***

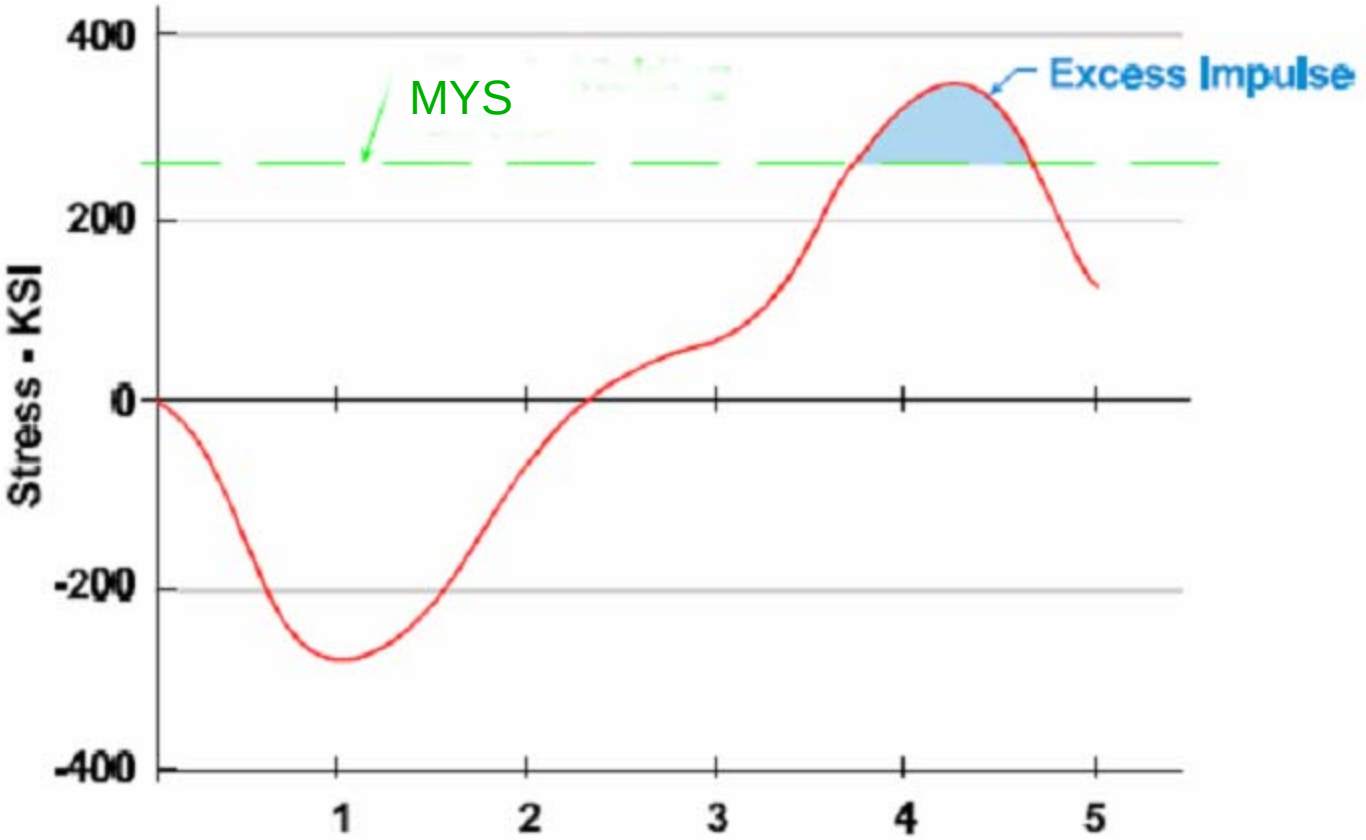
The Stress Measurement

- Rigid Body (RB) Movements (Axial tape measure but lateral micrometer) form basis of the Algorithm
  - Body encountering a resisting target with a force of opposite sense as velocity and proportional to V^2
  - Rise time equal to crater depth (Nose Length)
  - Axial RB Stress Waveform a non-structured trapezoid (= low frequency <100 Hz)
  - Lateral RB Stress Waveform a low frequency sinusoid (<500Hz)
  - Total (Heterodyned) Stress RB Waveform a non-structured Sinusoid (= low frequency extraction ~300 Hz)

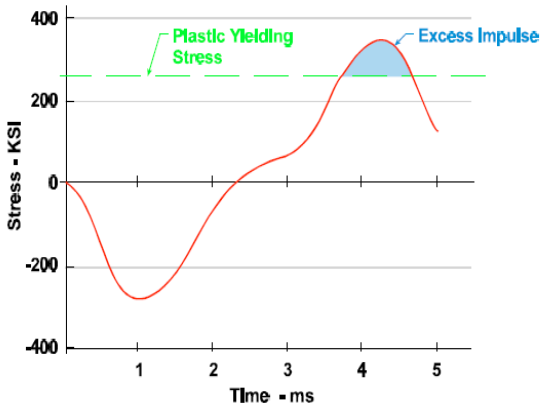
Axial Characteristics of RB Signal



Heterodyned Axial & Lateral Characteristics of RB Signal



Heterodyned Signal is the Running 'beat' of Axial and Lateral Case Stresses which forms a Low Frequency Sinusoid



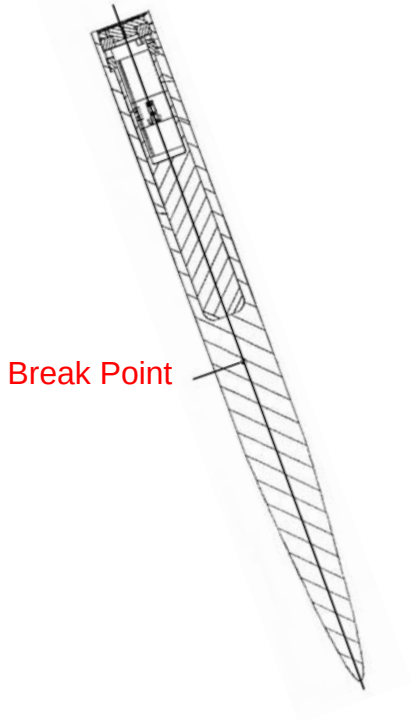
- A plastic yielding stress is defined; it is:
  - A Modified Yield Strength (MYS) which
    - Takes into account strain rate effects and
    - Is approximately 20% higher than yield
- When the Heterodyned Signal exceeds the MYS
  - The area (Integral above MYS) is defined as an excess impulse (EI)
  - The maximum allowable excess impulse (MAEI) is defined as the "Failure Criteria" (point)
  - And thus a singular value (empirically determined) annunciates failure

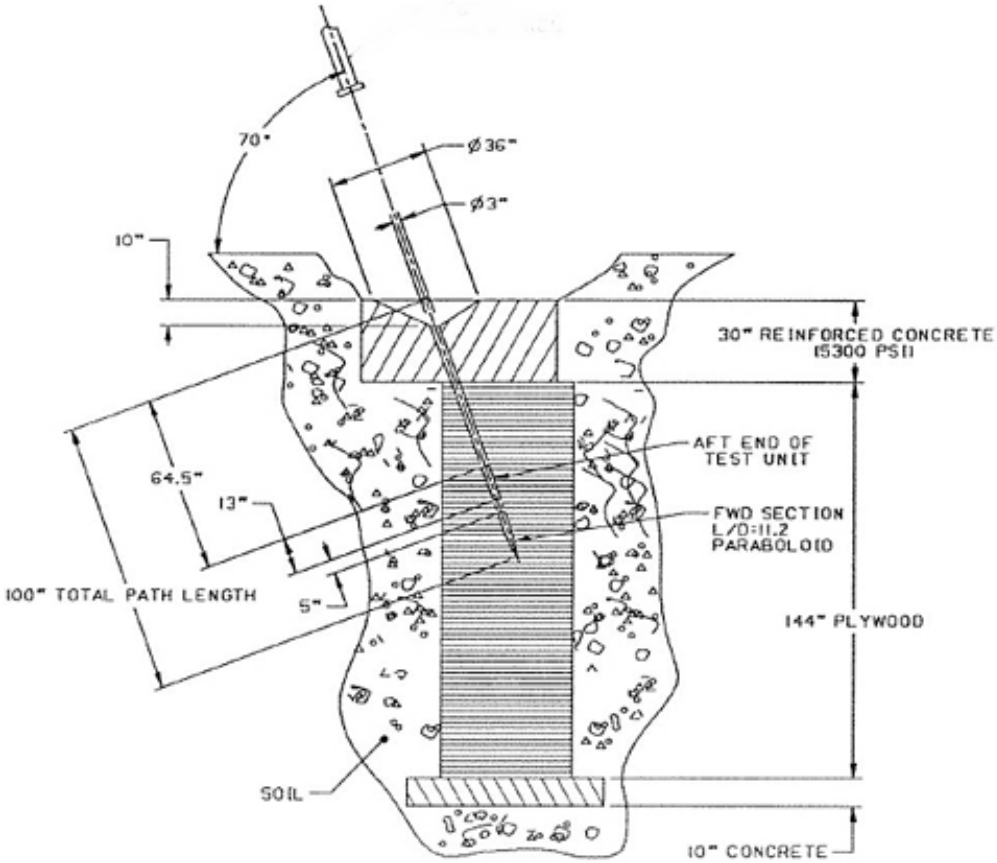
Testing the Robustness of the EI Algorithm

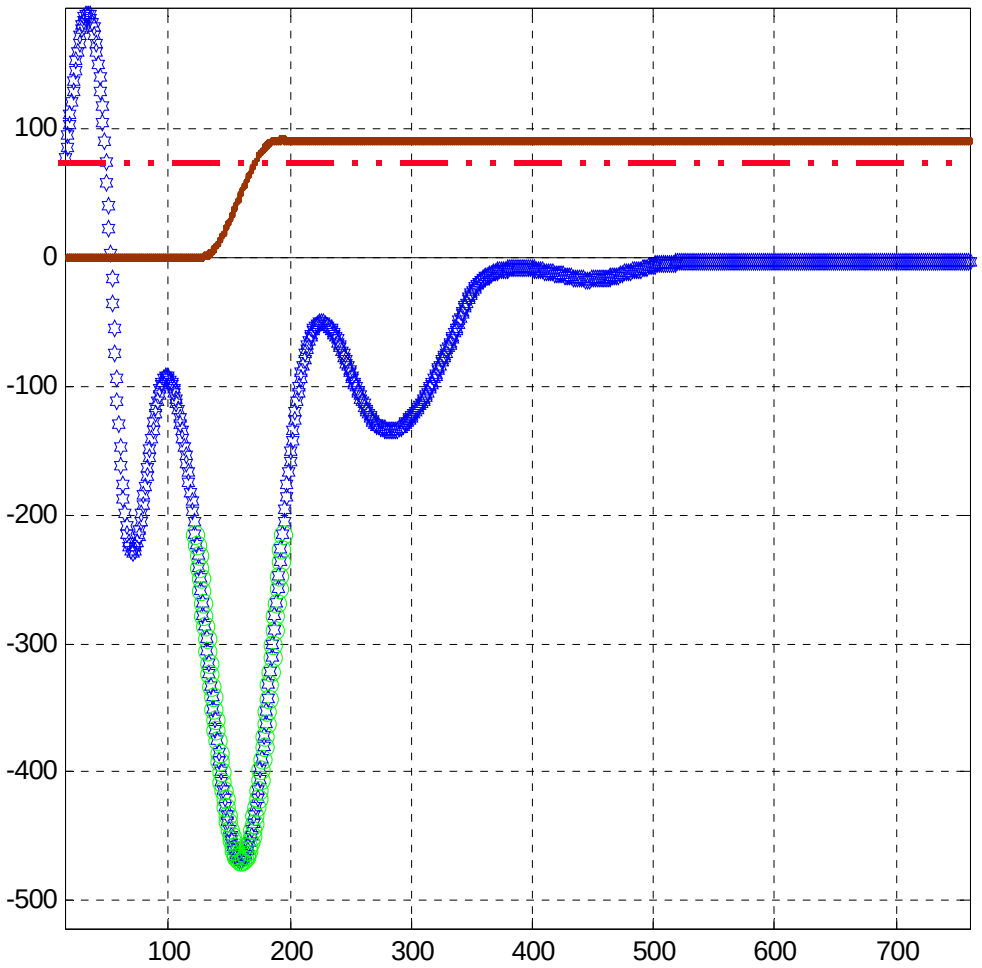
- First the MYS value is selected for the Device Under Test
  - While Scaled from Empirically based knowledge and Somewhat Arbitrary it:
    - Is selected in the plastic regime of the material stress strain curve
      - Since area within the linear elastic region (LER) is not of concern and
      - Short excursion into the plastic regime are not of concern and
      - Selection in the LER would desensitize the MAEI
- Second the initial conditions for the DUT are calculated to exceed the failure criteria
- The Device is tested, under these conditions, to failure and the EI algorithm failure criteria exactly determined
- By scaling, the EI value for the entire family of weapon enclosure failure points is determined
- Low cost scaled family testing is utilized to empirically determine the critical point as:
  - Signal Strength is not effected by scale leaving electrical and calculation systems unaffected
  - The selected scales maintain constant strain rate effects for the rest of the family

Verification Test No. 1 – OD 2.7” – L/D 11.2 – W 38# - 2 Degrees Nose Up

Velocity = 1200’/sec



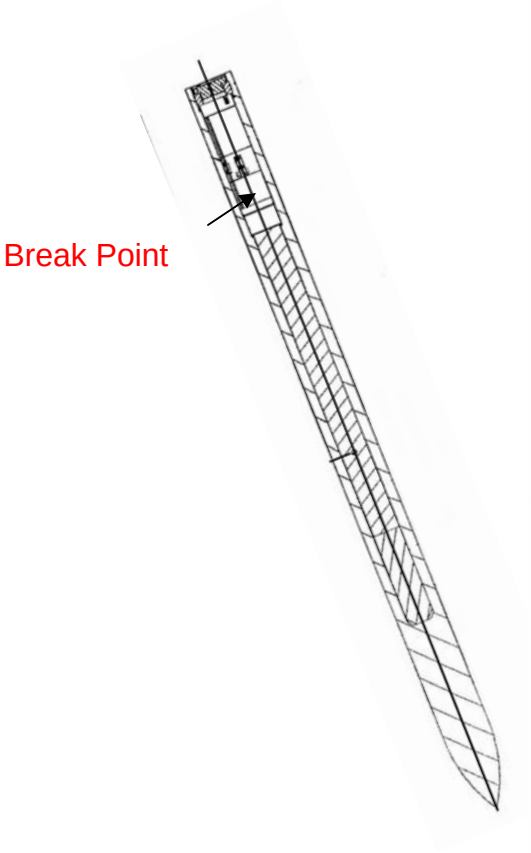


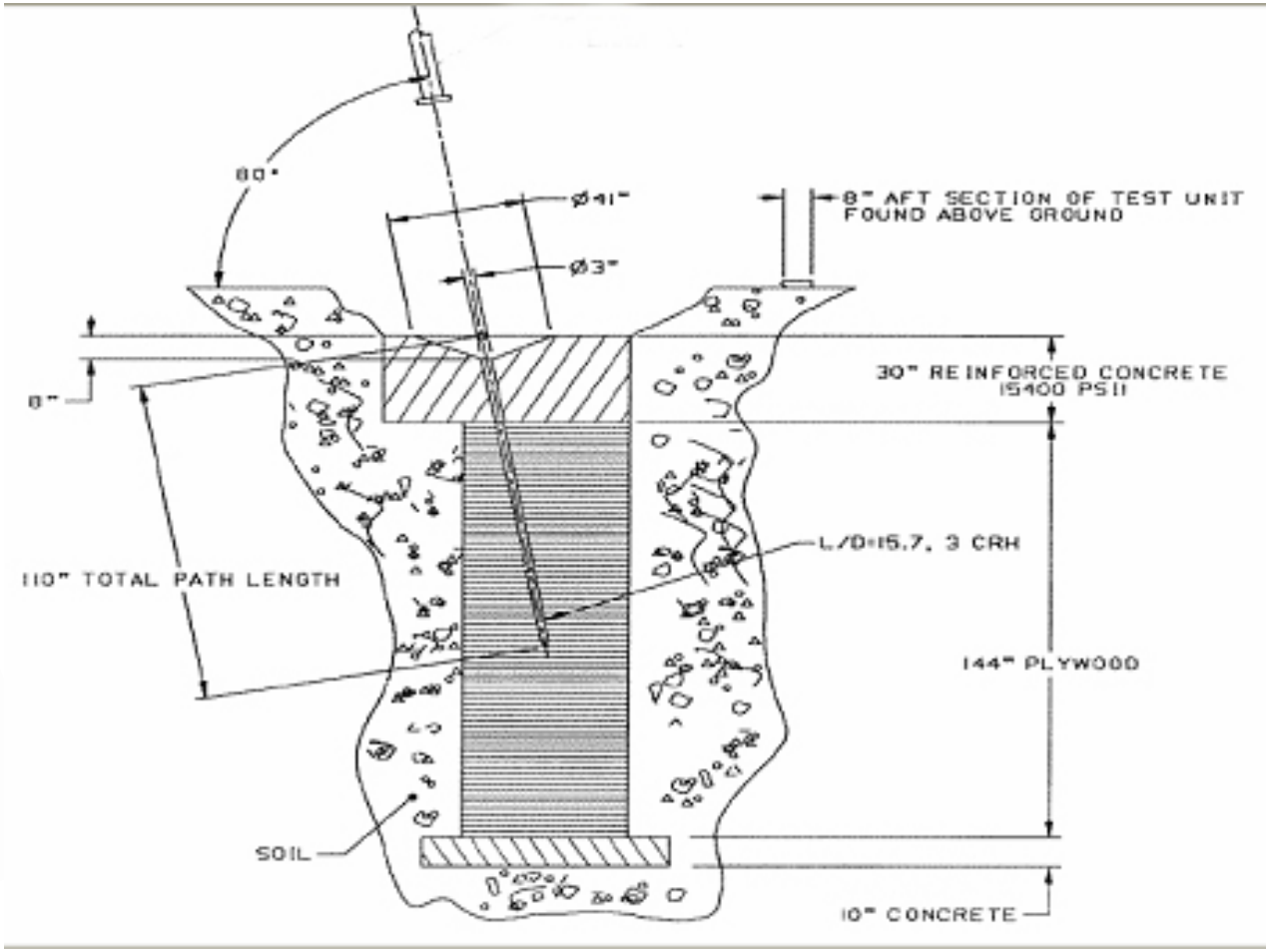


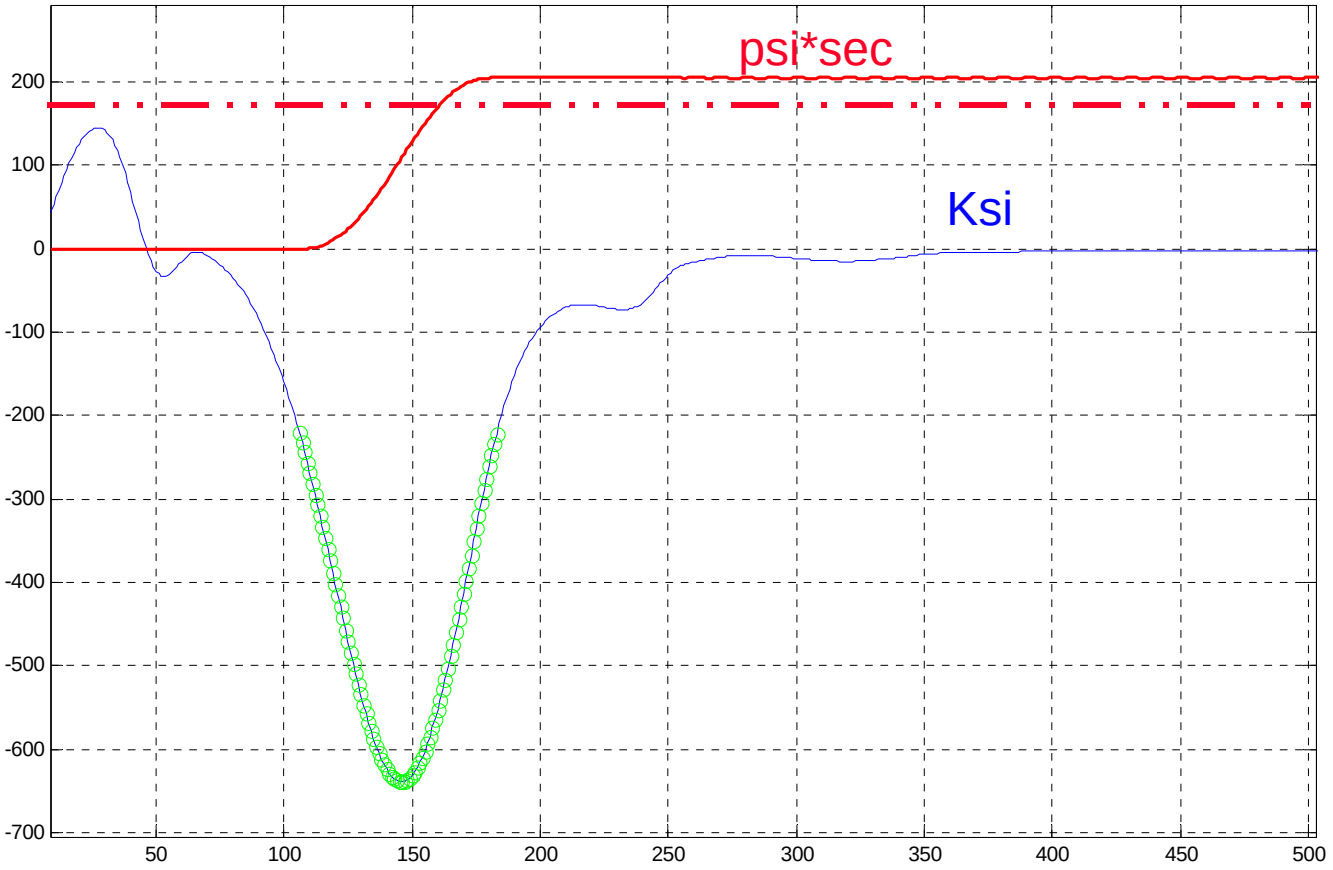
Heterodyned Stress Signal, **Excess Impulse Integral**, and Integration Area

Test No. 2 – OD 2.25” – L/D 15.7 – W 38# - 2 Degrees Nose Up

Velocity = 1170’/sec

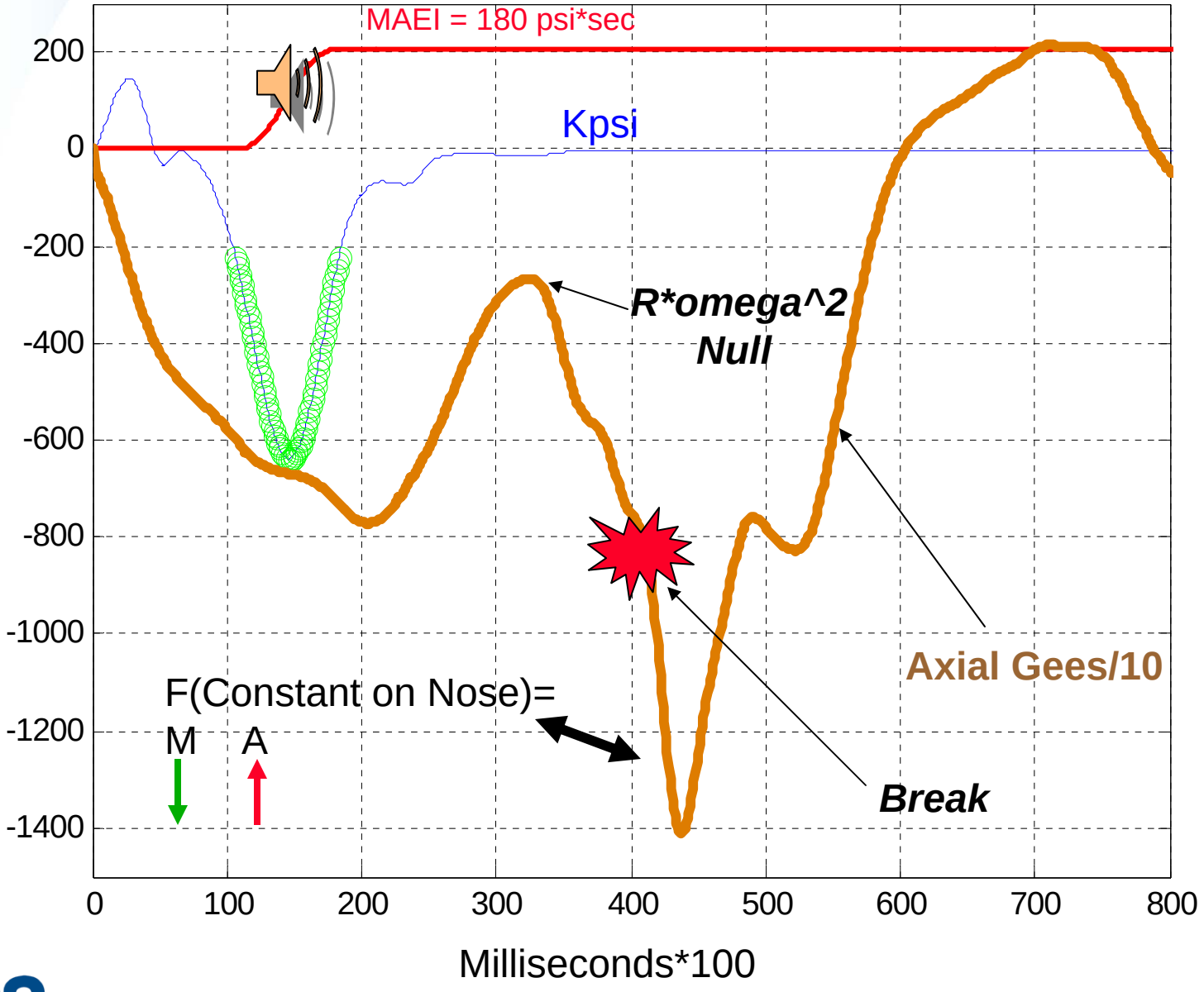






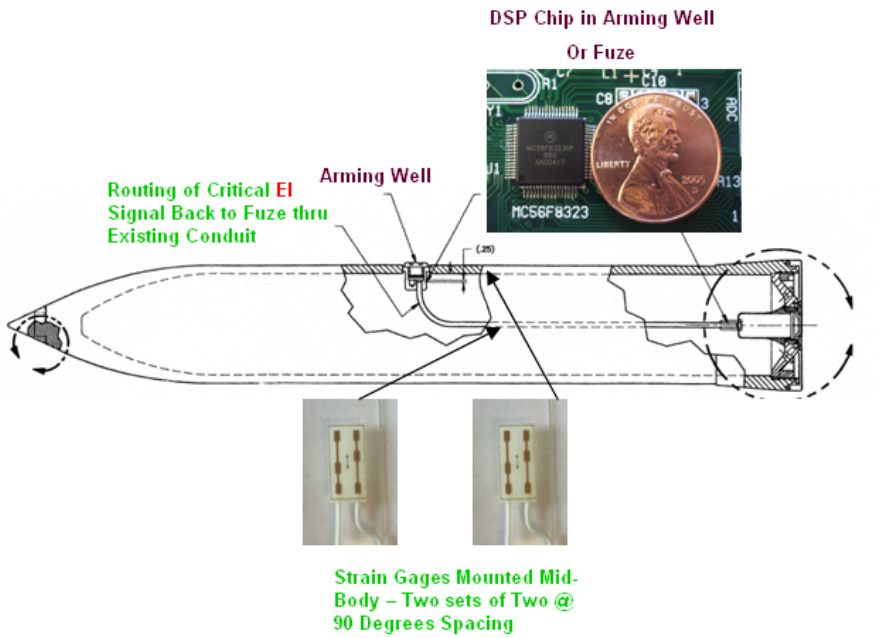
Heterodyned Stress Signal, Excess Impulse Integral, and Integration Area

Do We Signal in Time? *YES*



An Example

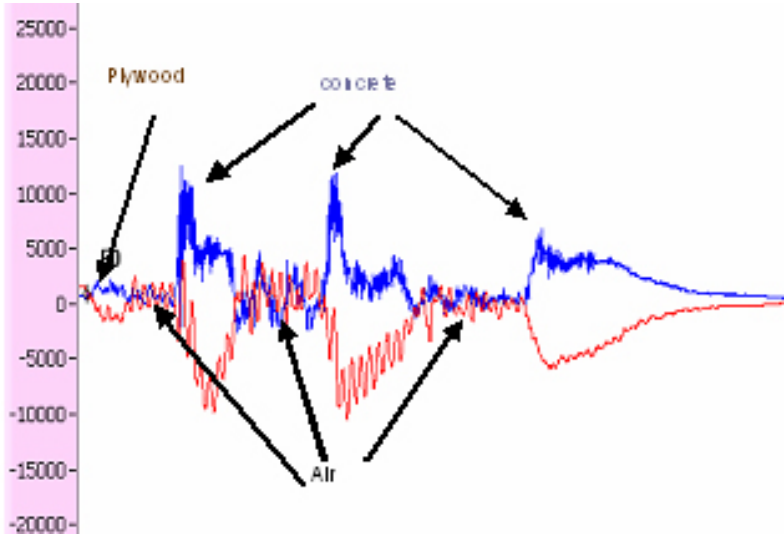
- Axial & Lateral low cost Semi-conductor strain gages are placed near CG
- Set duplicated at a point 90 degrees rotated from the first
- First set is on nose to tail axis
- Thin wires routed underneath aspaltic primer to fuze where bridge power is picked up or fzu power used and fire signal impressed on existing wires then demodulated at fuze
- Gages produce ~1 volt signal and case acts as anti- alias filter
- Heterodyned Signal directly connected to chip A/D. No amplifier, no filter. Chip extracts the low frequency component (filter) or digital beating is used
- ***This DSP microcontroller chip with GPIO makes the integration, interprets the result, outputs command to fire when critical EI value is reached***



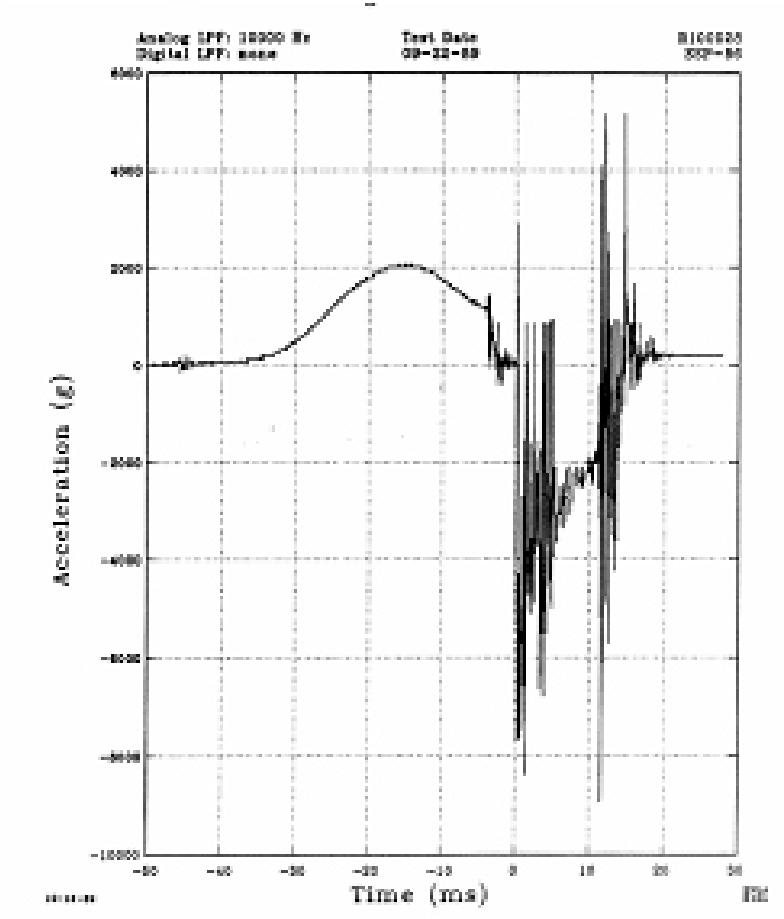
This example can be applied to any weapon case of any geometry

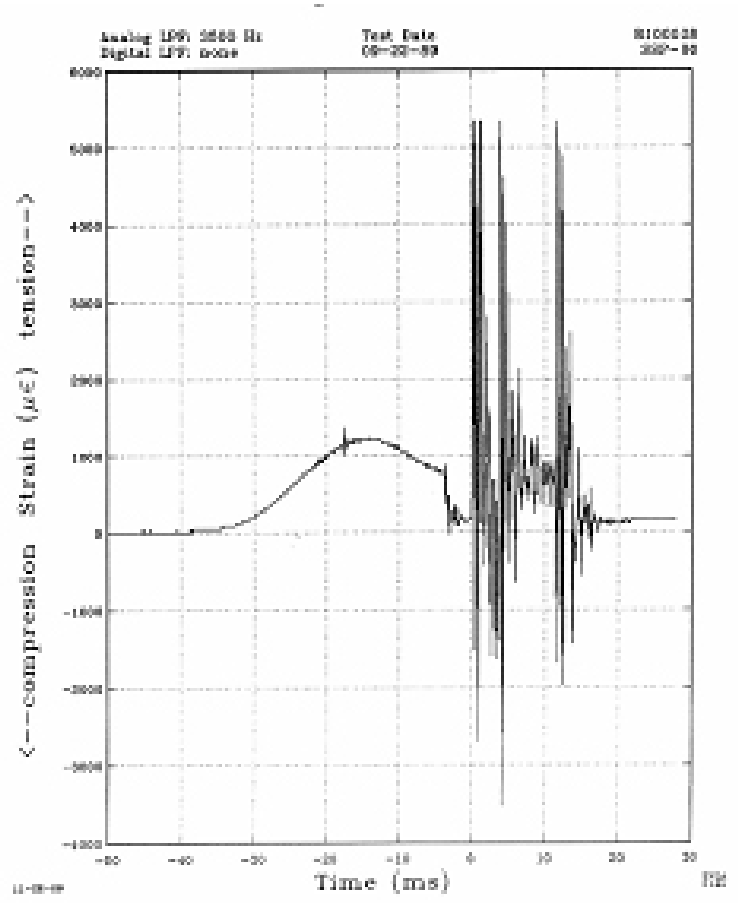
An Additional Use of the Strain Sensor

- The axial sensing gages in previous example will reproduce rigid body deceleration.
- The case mass above the gages provide enough impetus to preserve a robust SNR
- To the right results from an Edisonion Effort to:
  - Compare 7270 to Strain Gage
  - 100 # projectile @ 2500'/sec
  - Multilayer Target consisting of:
    - Concrete
    - Plywood
    - Air
- As shown the agreement is good and in this case preserves area.
- Thus, the sensor can act as a layer detector at 1/1000 of the cost. The controller need only be re-programmed with a detection algorithm



Another Comparison
1400’/sec 800 # Accel vs Strain





Program Accomplishments

- *A Means & Method to:*
  - *Detect and Monitor Stresses Caused by:*
    - *Weapon Case Axial Loads*
    - *Weapon Case Lateral Loads and*
  - *Distinguish Between Normal and Deleterious Stress Conditions*

  Was developed
- *The Method was Verified Against Real World Events*
- *Detection algorithm was developed*
- *A preliminary Design of the Damage Signaling Circuitry was completed*
- *Alternative smart uses of strain gages verified thru Edisonion methods*

NDIA – 53rd Annual Fuze Conference

"Next Generation Fuzing – Maximum Advantage for the Warfighter"

XM1156 Precision Guidance Kit (PGK) Overview



20 May 2009

Peter Burke PM CAS

Tony Pergolizzi ARDEC AFMO (Presenter)

PGK Overview

- **XM1156 Precision Guidance Kit (PGK) Is A GPS Guidance Kit with Fuzing Functions to Reduce Ballistic Dispersion of Artillery Projectiles**
  - Increment 1: ≤ 50m CEP for 155mm High Explosive (HE) projectiles
  - Future Increments will develop compatibility for 105mm projectiles, cargo projectiles, and future artillery platforms

- **Alliant Techsystems (ATK, Plymouth, Minnesota) was awarded the Increment 1 System Development and Demonstration (SDD) option based on competitive shoot-off**

- **PGK program has completed its Hardware Critical Design Review and is beginning government qualification testing this summer**

- **PGK is scheduled to begin production in 3Q US Fiscal Year 2009, and be fielded in Fiscal Year 2010**

PGK Projectiles & Platforms

PGK Projectiles with M109A6 (Paladin)



M777A2



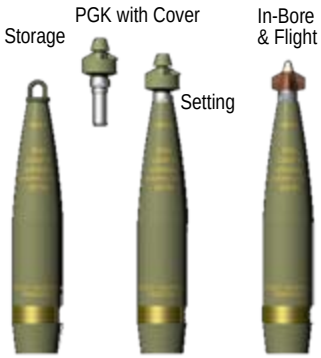
<u>M107</u>
- 95 lbs
- Max Range* 17.5Km
- Warhead 15 lbs

<u>M549/A1</u>
- 96 lbs
- Max Range* 30Km
- Rocket Assisted
- Warhead 15 lbs

<u>M795</u>
- 103 lbs
- Max Range 22.5Km
- Warhead 23.8 lbs

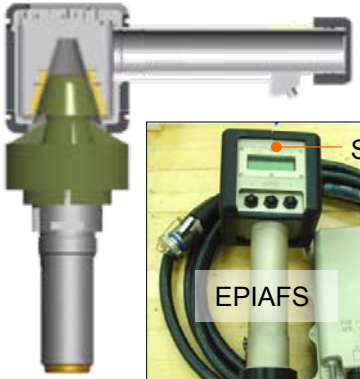
* Maximum Range without PGK shown. Max Range will be reduced by no more than 10% with PGK

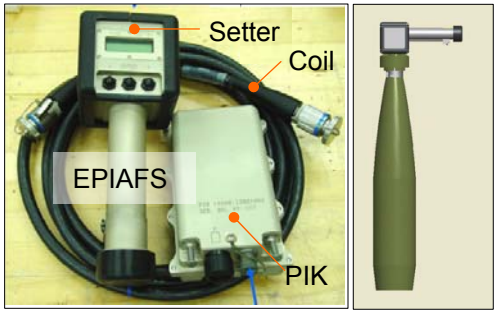
Precision PGK Mission



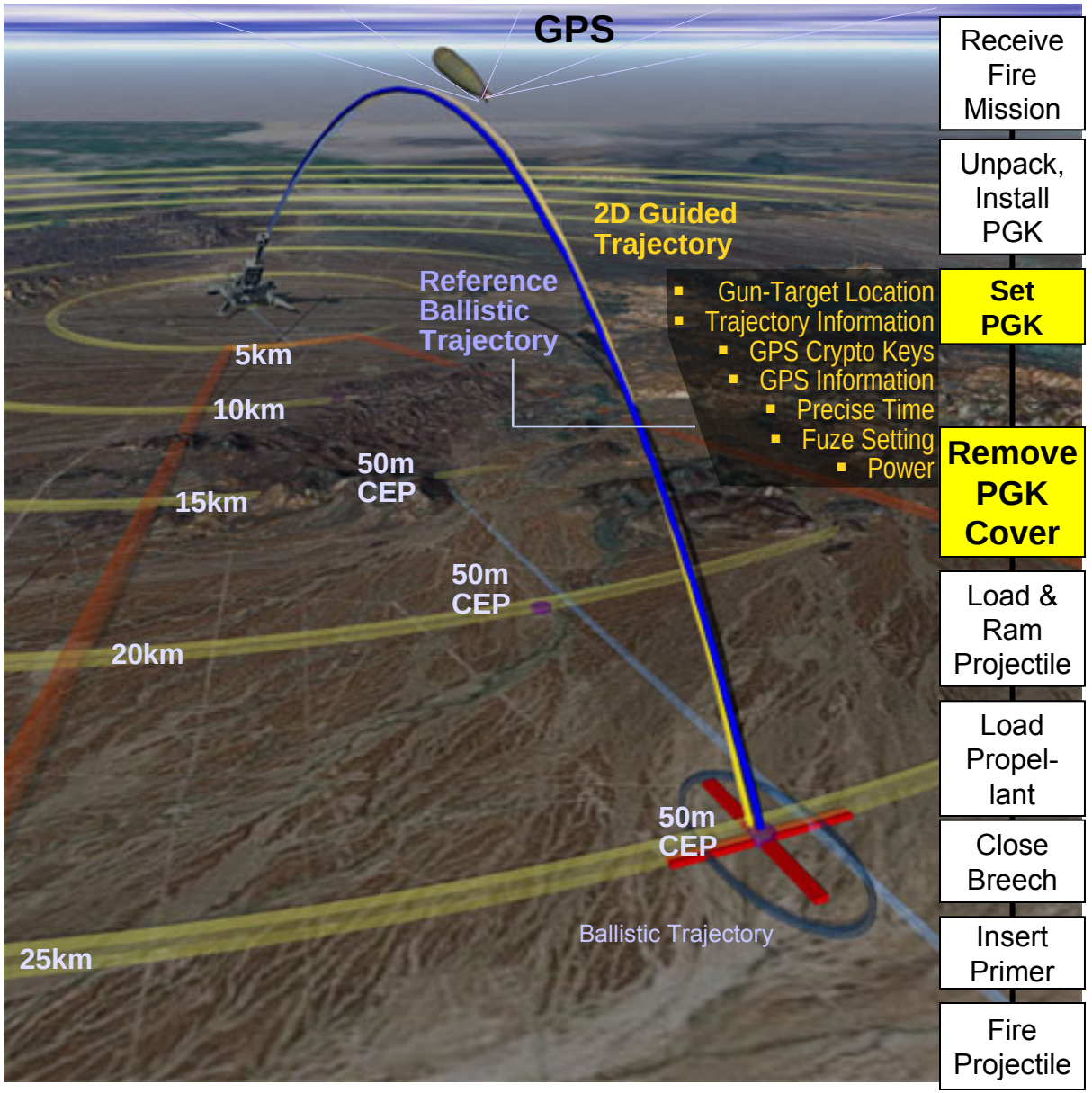


Planning the PGK Mission









Receive Fire Mission

Unpack, Install PGK

Set PGK

Remove PGK Cover

Load & Ram Projectile

Load Propel-lant

Close Breech

Insert Primer

Fire Projectile

Comparative 155mm Projectile Accuracies

The Most Cost-Effective Munition Will Be Chosen Based on Mission Need:

- Target Defeat Capability
- Collateral Damage Risk



M549A1 with PGK



M549A1

15 km — 50 m

20 km — 50 m

25 km — 50 m

30 km — 50 m

94 m

125 m

150 m

267 m

All using 1/2 hour old Meteorological data

Circles represent accuracy in terms of CEP (Circular Error Probable) at different operational ranges from the firing platform

PGK Requirements

JROC Approved (Increment 1) 22 Jan 2007

	Increment 1 IOC FY10	Increment 2 IOC FY13	Increment 3 IOC FY16
Key Performance Parameters			
1. Net Ready	→	→	→
2. Reliability	92% (T); 97% (O) →	→	→
3. Accuracy	≤ 50m CEP (T); ≤ 30m CEP (O)	≤ 30m CEP (T=O)	≤ 30m CEP (T); ≤ 20m CEP (O)
Attributes			
Munition Type	155mm HE (M107, M795, M549A1)	Adds 105mm HE (T); 105/155mm HE & Cargo (O)	155mm HE (T); 105/155mm HE & Cargo (O)
Platform Types	M777A2, Paladin	Adds M119A3 (105mm) (T); NLOS-C (O)	Adds NLOS-C (T); Paladin, M777A2, M119A3 (O)
Fuzing Function	PD, Proximity	Adds Delay & Time (O) →	→

T: Threshold Requirement
O: Objective Requirement

Enhanced Portable Inductive Artillery Fuze Setter (EPIAFS) and Platform Integration Kit (PIK)



DAGR



- EPIAFS:
  - Conventional Fuze & Excalibur/PGK Setter
  - Programs Excalibur & PGK with mission information
- Platform Integration Kit
  - Interface circuit from platform fire control systems, DAGR (GPS receiver) to EPIAFS

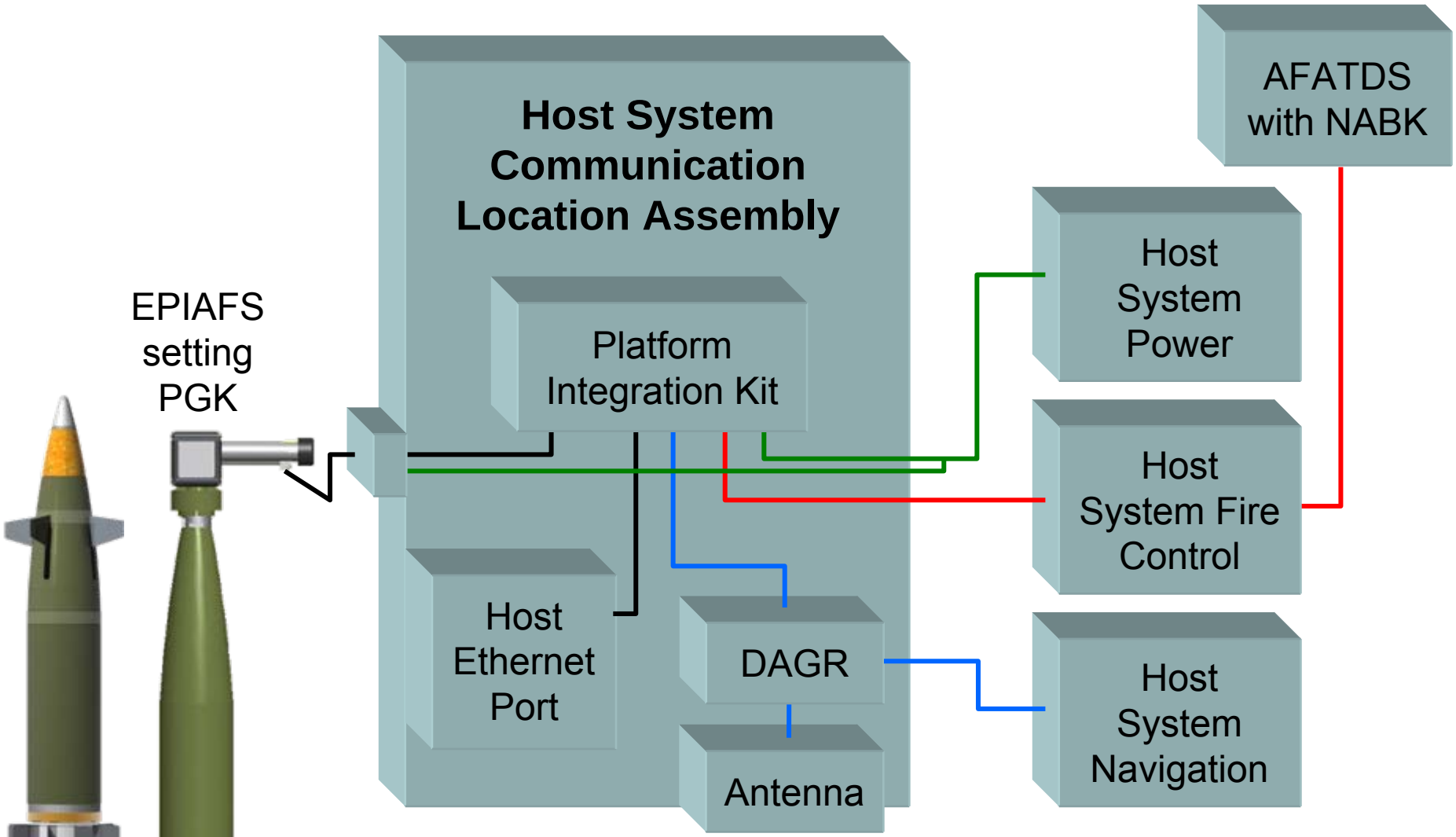


PIK in M109A6 (Paladin)



PIK on M777A2

EPIAFS Interface & Host System Support

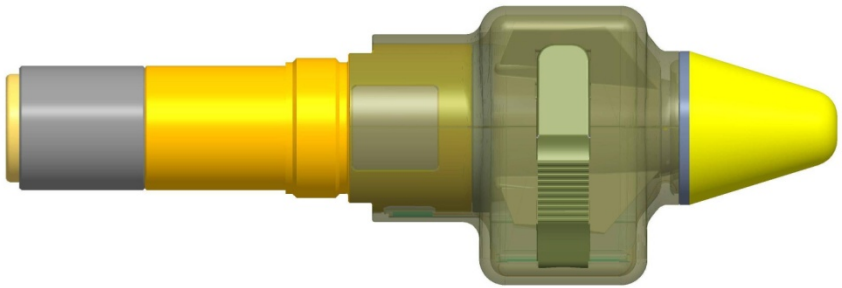


Compatible with Excalibur & PGK

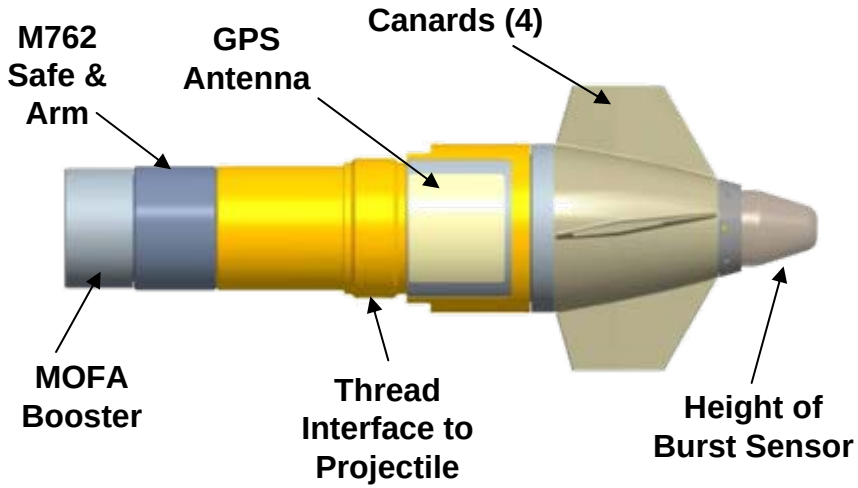
PGK Design Description

PGK With Cover

Cover Provides Environmental Protection & Interface to Fuze Setter

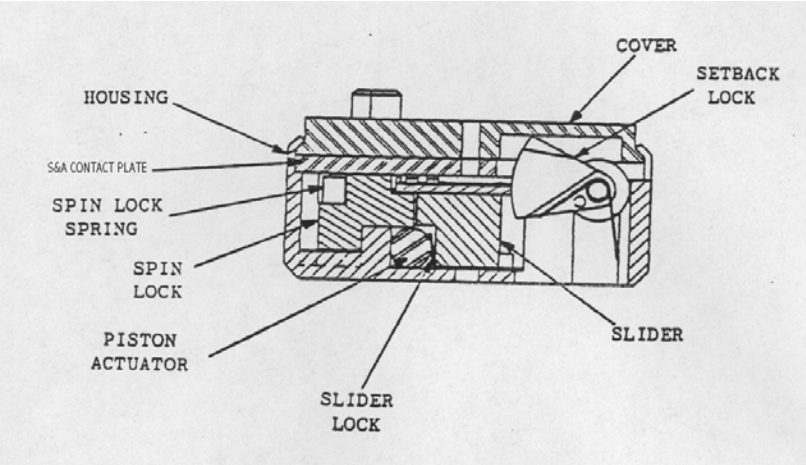


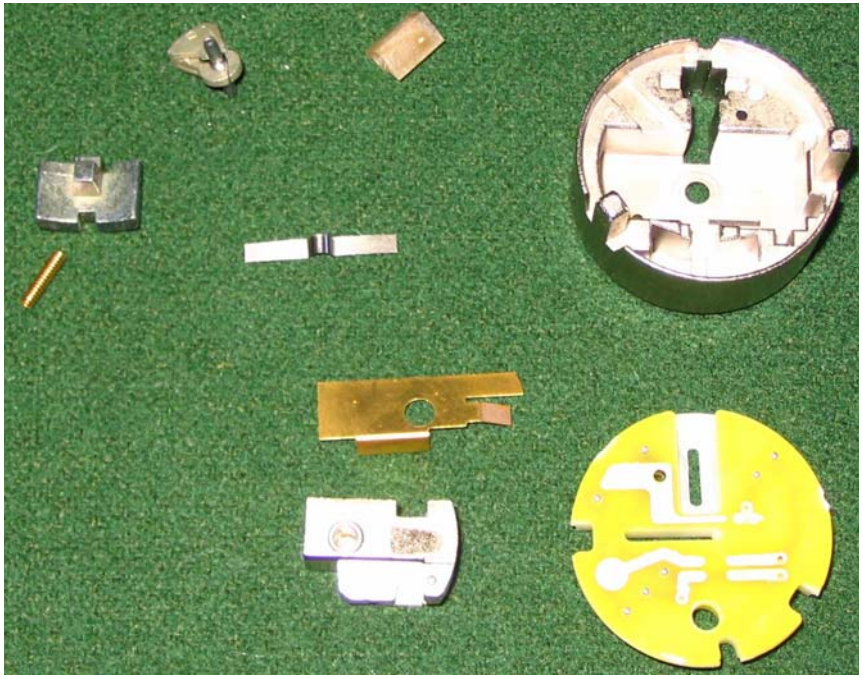
PGK with Cover Removed

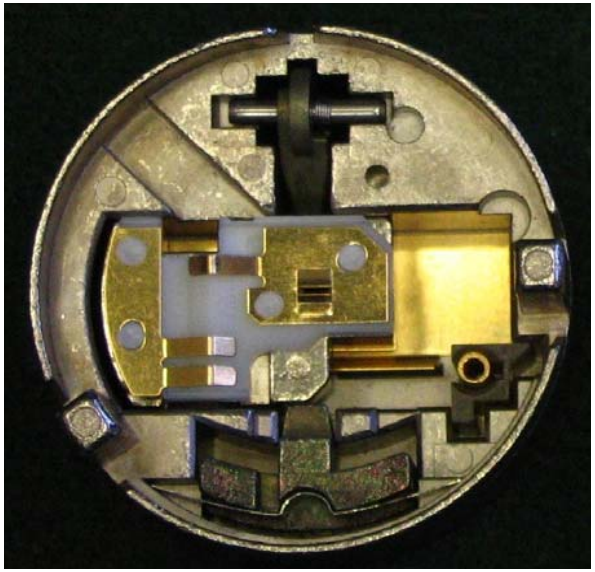


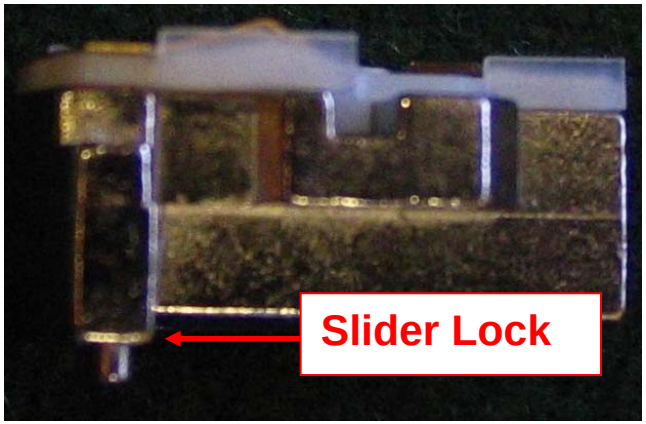
- Fits In Std 155mm HE Artillery Projectile Fuze Wells (Deep Intrusion)
- GPS Guidance (With SAASM)
- 20 Year Storage Life (No Battery)
- Proximity & Point Detonating Fuzing

M767A1 Safe & Arm (S&A) Mechanism





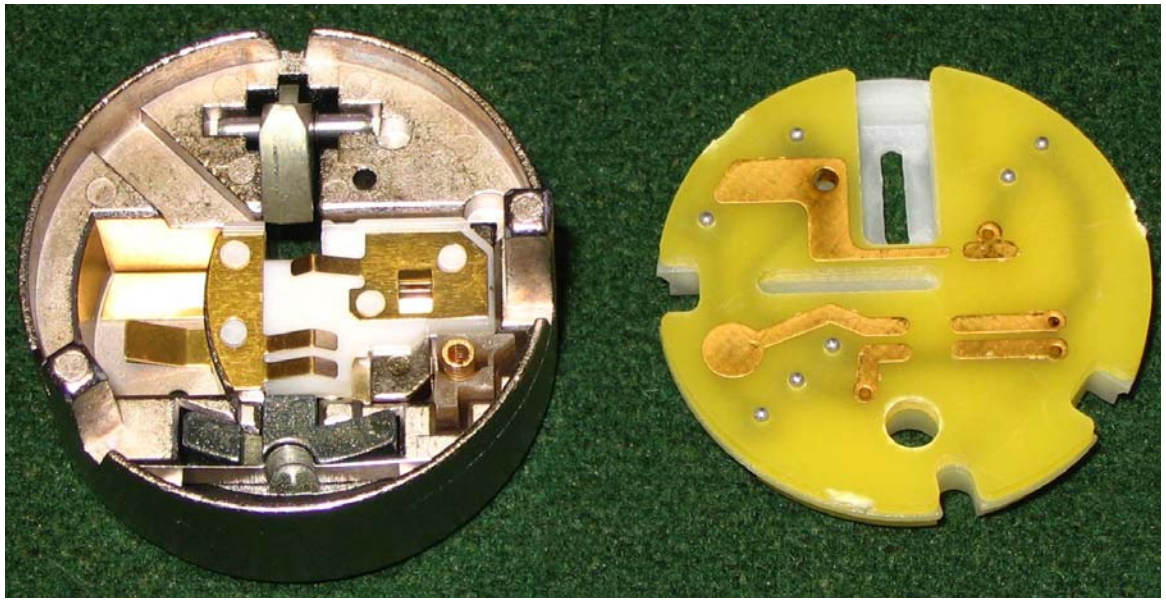


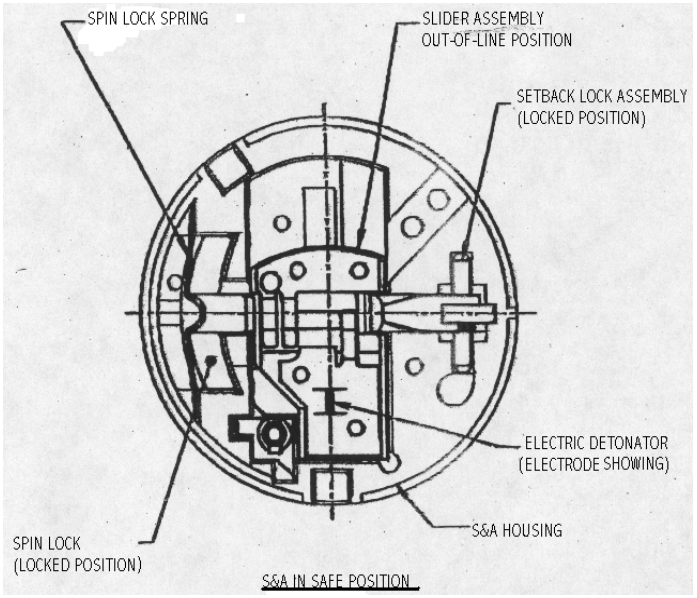




Safe Position

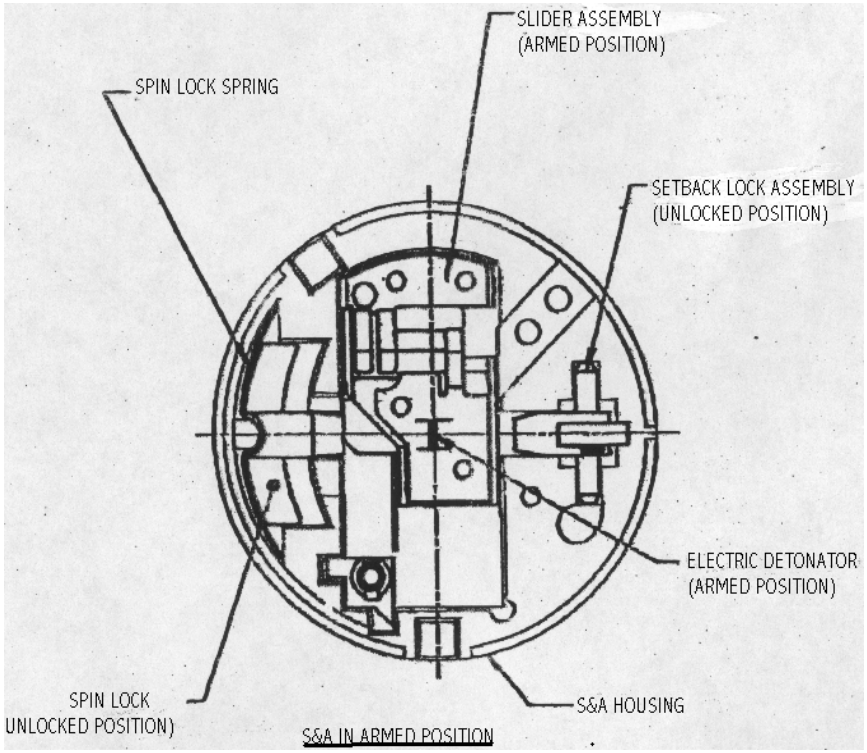
- Setback weight up
- Spin lock pushed in

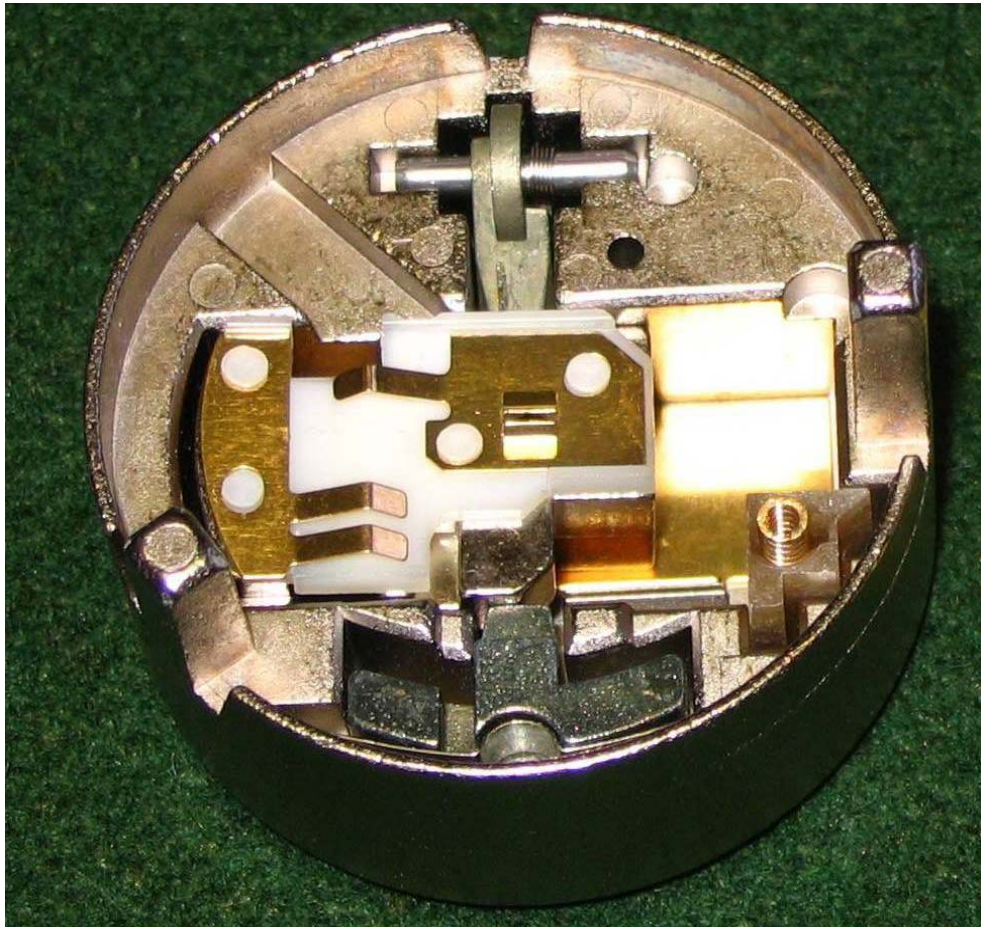




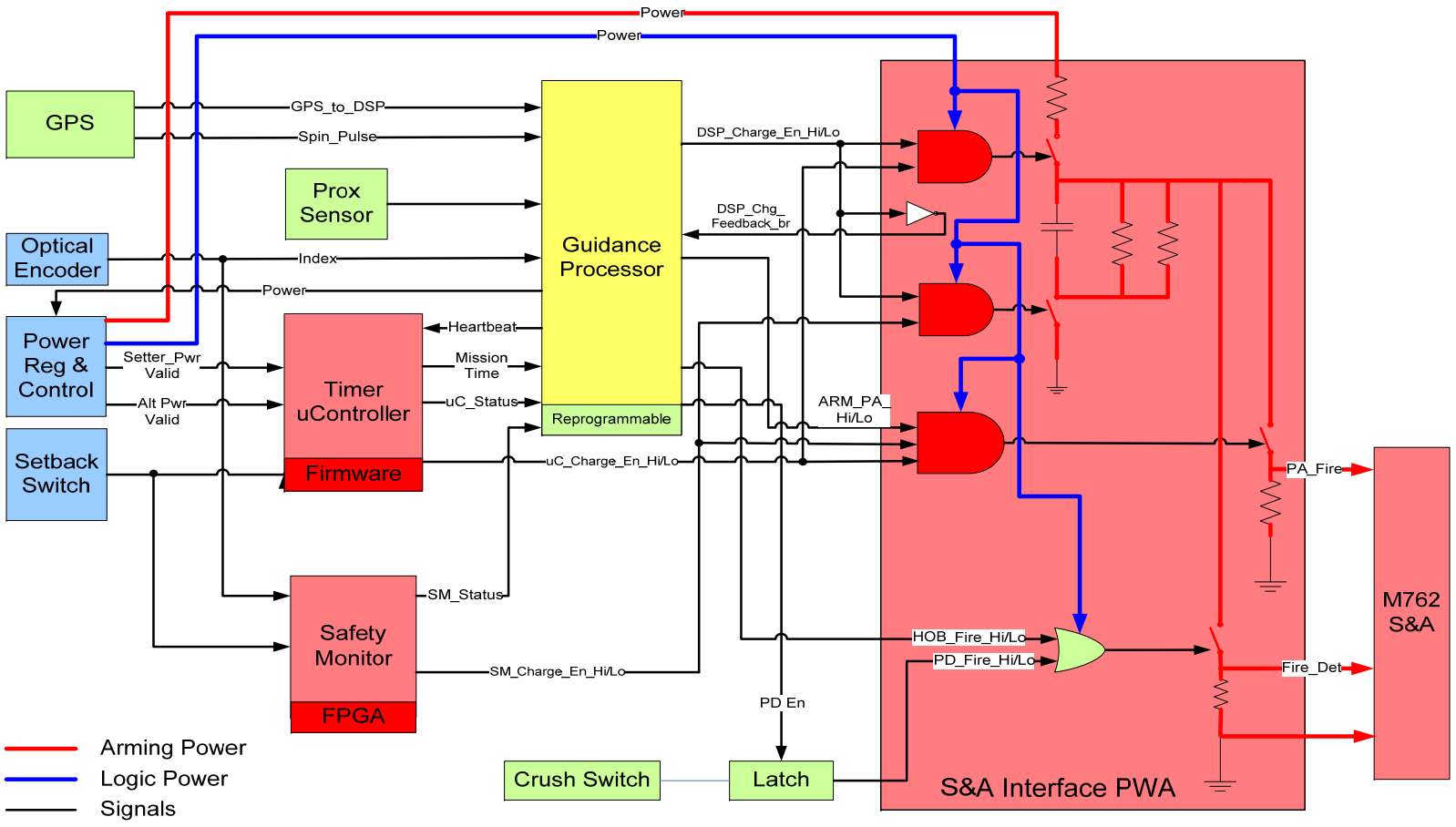
Armed Position

- Setback weight down
- Spin lock pushed out





PGK Fuzing Architecture



PGK Accomplishments & Up-Coming Events



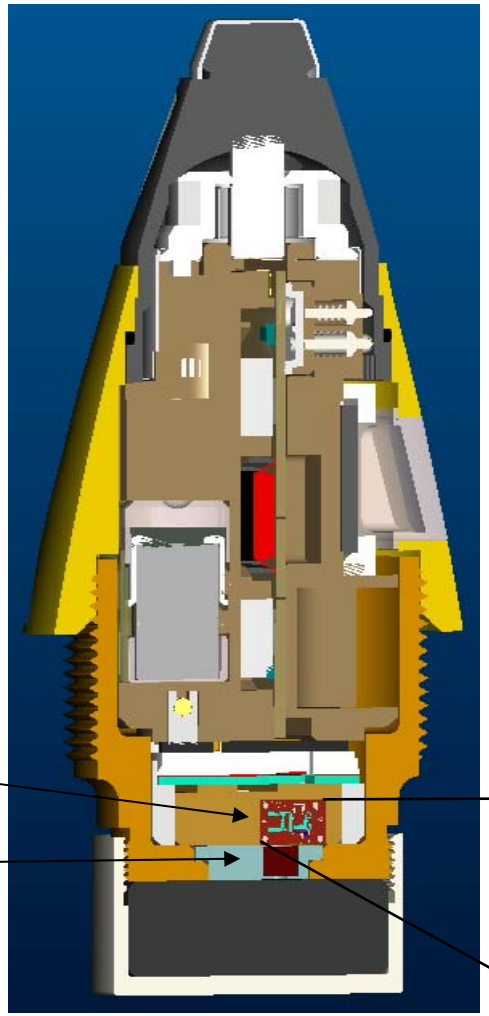
- Hardware CDR -- Jan 09
  - Design Meets All Requirements Via Analysis or Testing
- AFSRB Initial Certification -- Feb 09
- Guide To Flight Tests – Apr 09
  - M795 Projectiles
  - Acquired GPS
  - Tracked and Guided
- Successful User Evaluation – Ft Sill, Apr 09
- Successful Vertical Gun Tests – May 09
  - M795 Projectiles (MACS Charge 4/5)
  - Hardware Survived Launch
  - Currently Being Electronically Evaluated at ATK
- Mil Std 331 Testing – Jun 09
- Environmentally Conditioned Ballistic Safety Tests – July – Sep 09
- Environmentally Conditioned Ballistic Performance Tests – Aug – Sep 09
- TC Standard – Sep 09

Future Advancements in Fuzing

Micro-Electro Mechanical Systems (MEMS) S&A Development



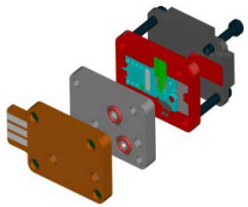
M762A1/M767A1

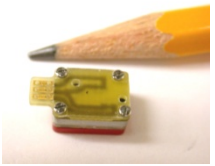


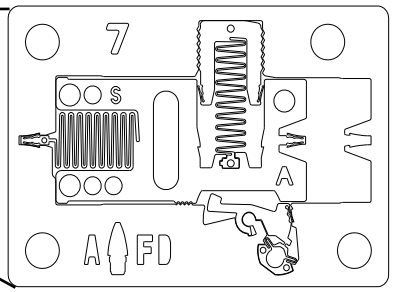
MEMS Integrated

M762A1 Fuze Used To Evaluate MEMS S&A Performance For Artillery

- Improved MEMS Design
- Suitable For High and Low Propellant Charges
- Command-To-Arm Feature
- ***S&A Volumetric Savings = 95%***

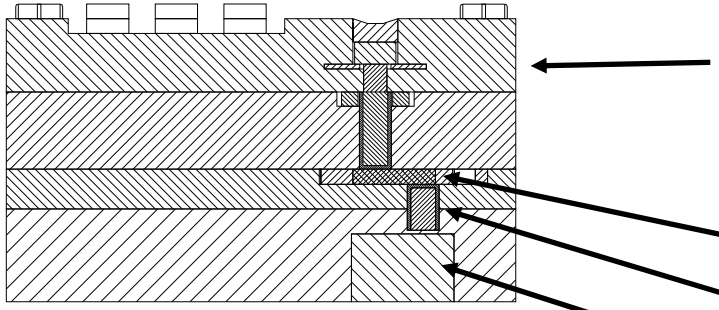






Micro-Scale Firetrain (MSF)

U.S. Patents 7055437 and 7069861



Cross-section, MEMS S&A Assembly

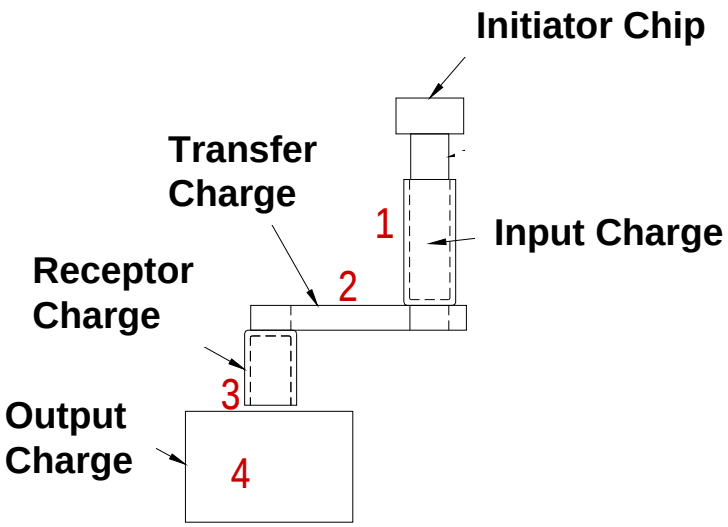


Initiator Board

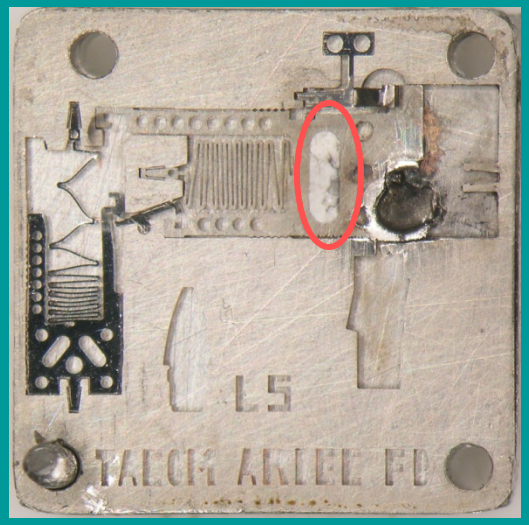
Transfer Charge

Receptor Charge

Output Charge



Barrier Safety







Charge 1 Function
Charge 2 (Transfer) Safe

Charge 3 (Receptor) Safe
Charge 4 (Output) Safe

Summary

- PGK (Increment 1) Provides Warfighter ≤ 50m (CEP)
  - 155mm High Explosive Projectiles
  - Future Increments Increase Cababilites For 105mm & 155mm Projectiles
- PGK Design Leverages Existing Technology (High Maturity)
- PGK Safety Design
  - Uses Proven M762 S&A Design
  - Redundant Electronic Architecture
- Warfighter Benefits Include:
  - Improves Munition Accuracy
  - Improves Munition Efficiency
  - Increased Number of Stowed Kills (Reduces Logistics Burden)
  - Greatly Reduces Possibility of Collateral Damage
- PGK Increment 1 Fielding Planned in US Fiscal Year 2010

JUNGHANS microtec





Future Fuzing: New Operational Needs and Fuze Technical Challenges

Max Perrin

53rd Annual Fuze Conference
May 19 - 21, 2009 – Lake Buena Vista, FL
"Next Generation Fuzing - Maximum Advantage for the Warfighter"

Company Presentation

JUNGHANS microtec

- **A global leader in the field of ammunition fuzes and S&A devices**
- **Full range of products**
- **Key competences in**
  - Fuzing technologies
  - Micro-technologies
  - Ammunition electronics





Fuze Missions

JUNGHANS microtec

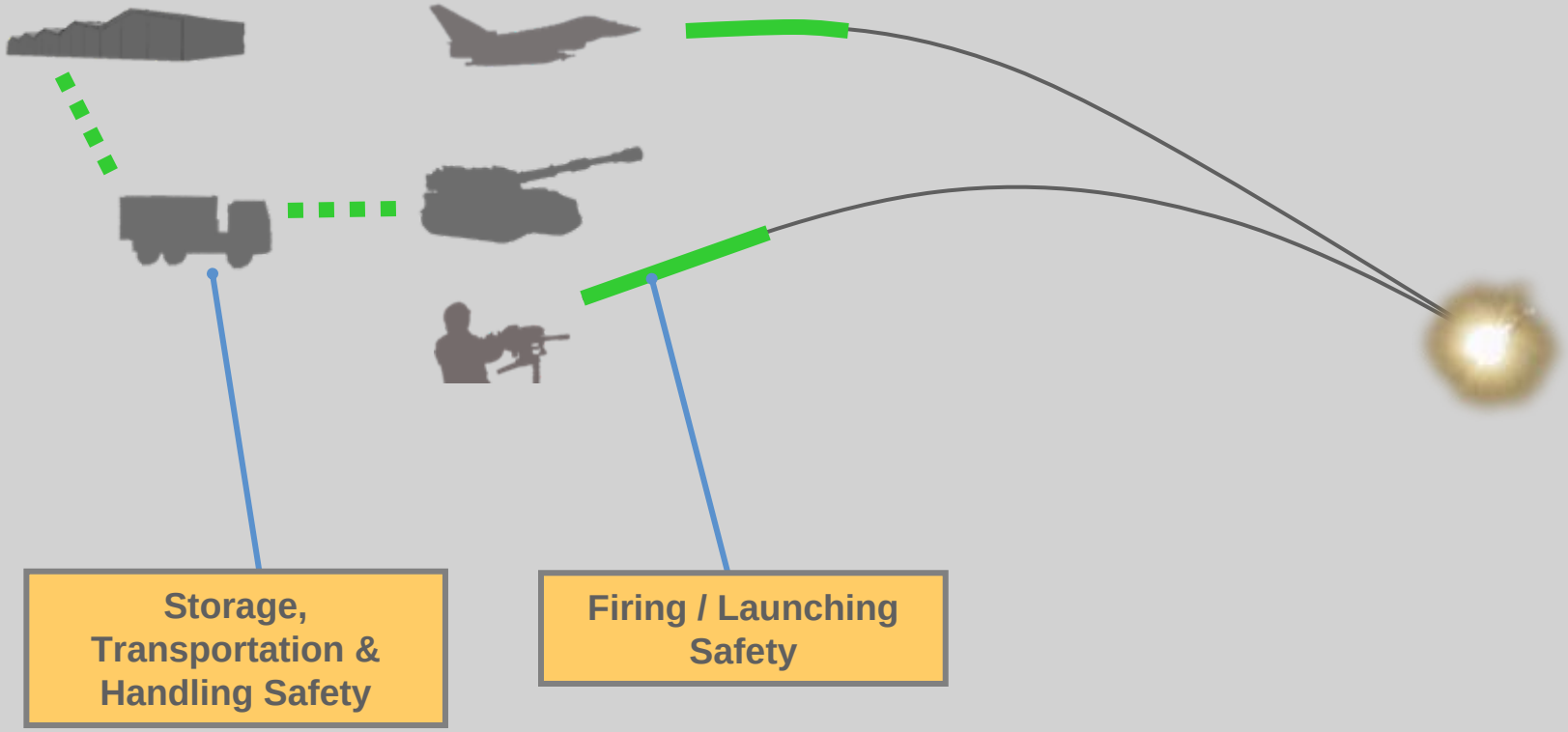
- The Fuze provides most of the performance of the munitions, in terms of:
  - ***Terminal Effect***: by optimizing the warhead initiation time/place/mode on target
  - ***Safety and Reliability***: by providing maximim safety for the friendly troops while dealing with enhanced reliability requirements (no hazardous duds)
  - ***Flexibility***: by enabling the user to always get the relevant product whatever the missions and the threats are, and reducing the logistic footprint
- New trends in modern warfare highlight new operational needs

New operational requirements for munitions

=

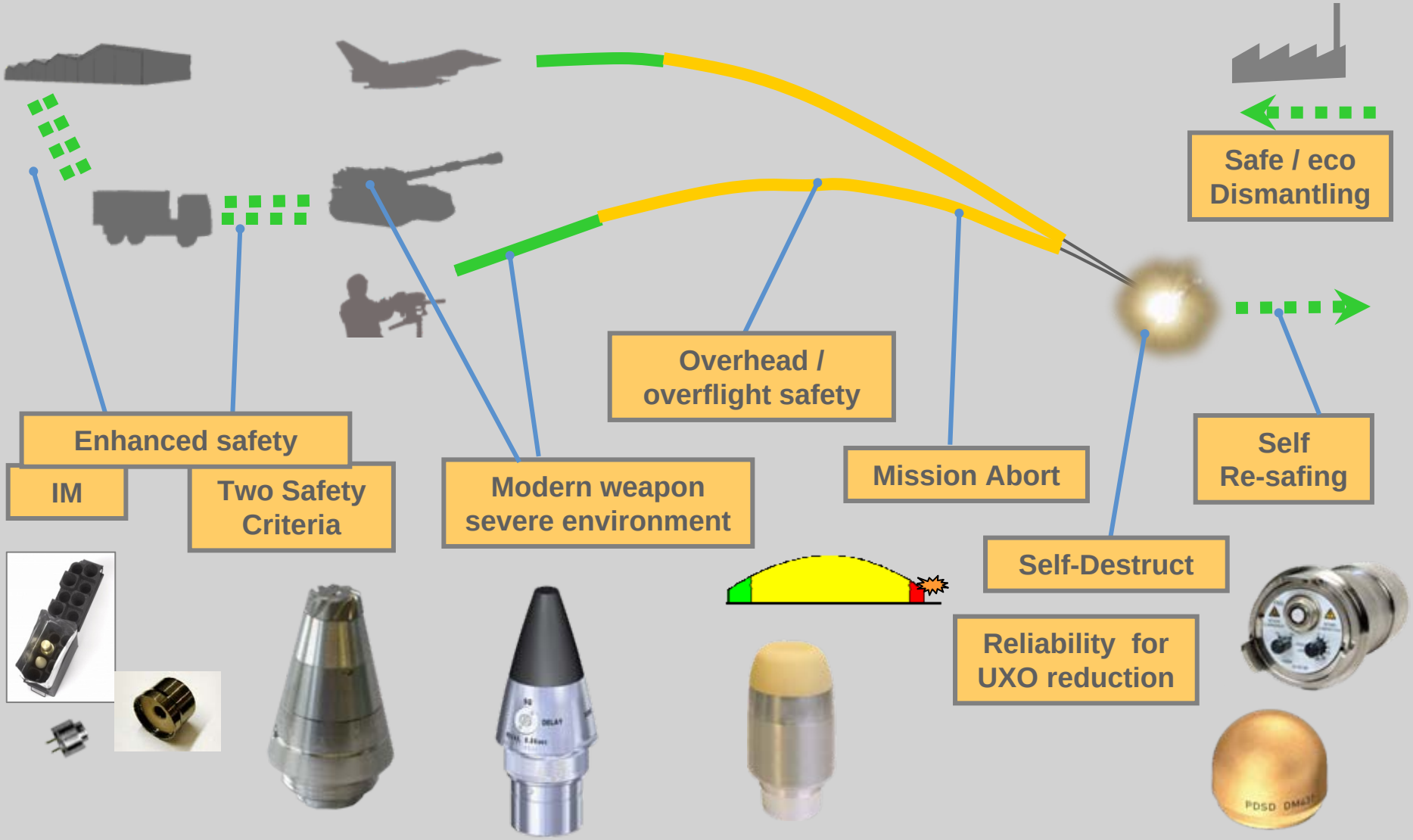
Improvement of fuze functions and
Development of new technologies for fuzes

Safety: Conventional requirements

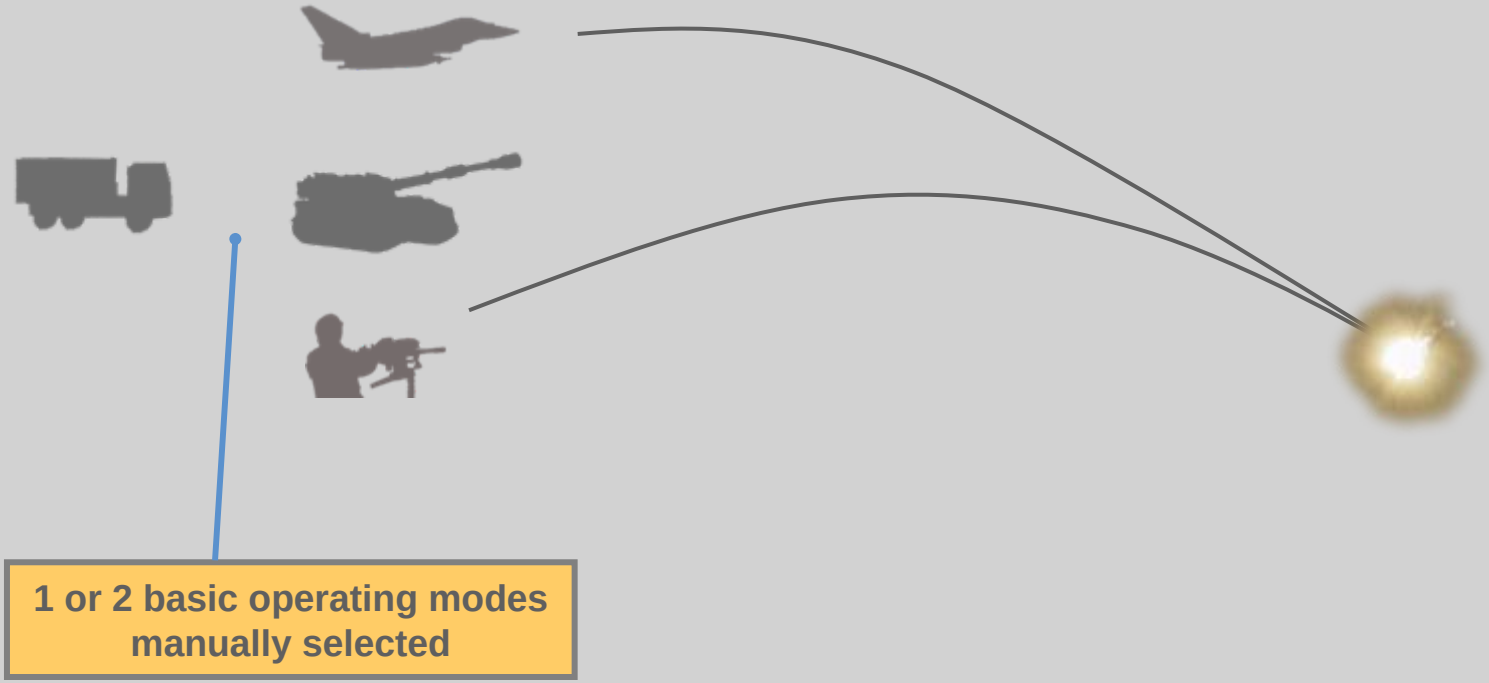


Safety: New operational requirements

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Flexibility : Conventional requirements

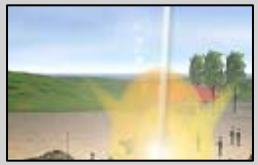


1 or 2 basic operating modes manually selected

Flexibility : New operational requirements

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Fuze Setting

All parameters

Automatic

Multi-mission Multi-function

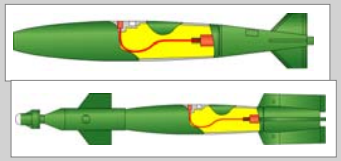
Activity Control

Mission Abort

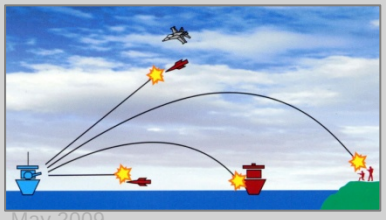
Target conf.

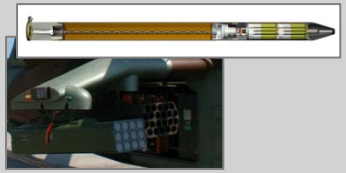
Terminal Effect Control

Logistic Footprint Reduction



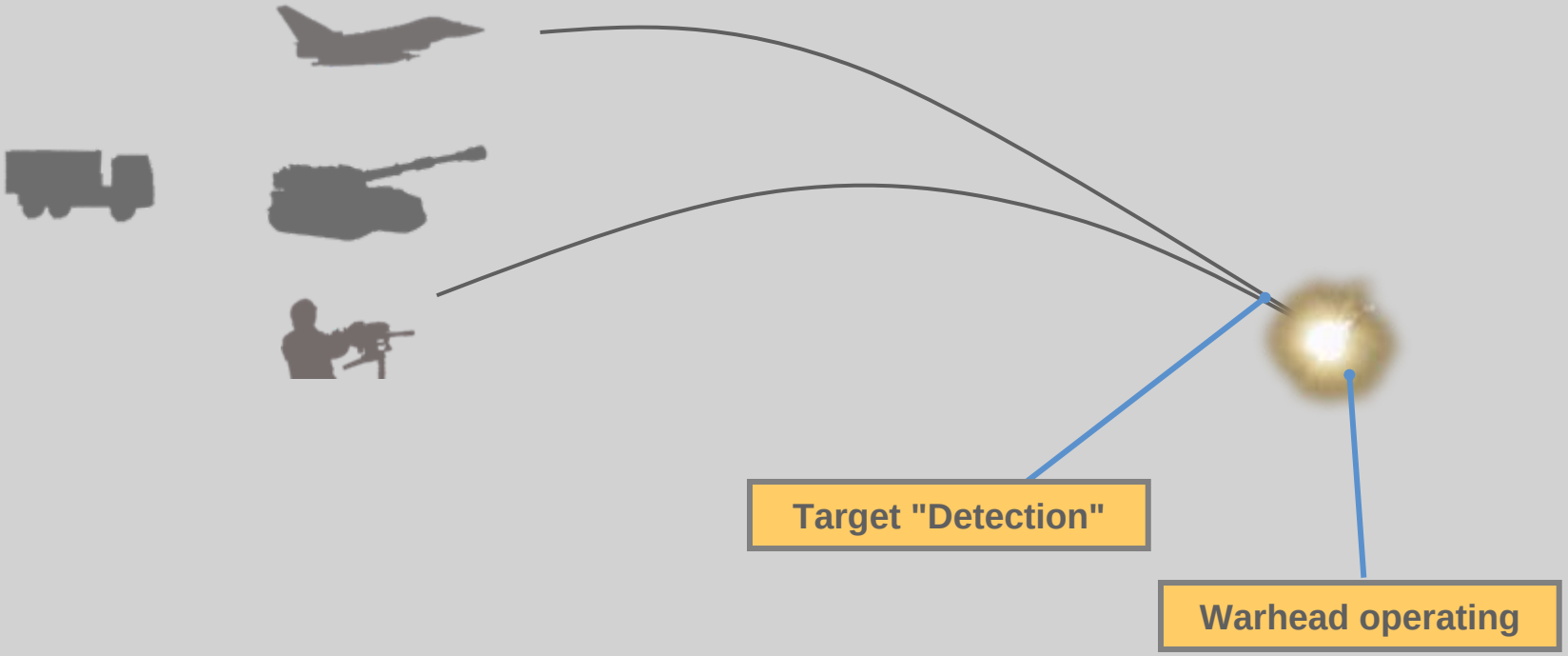






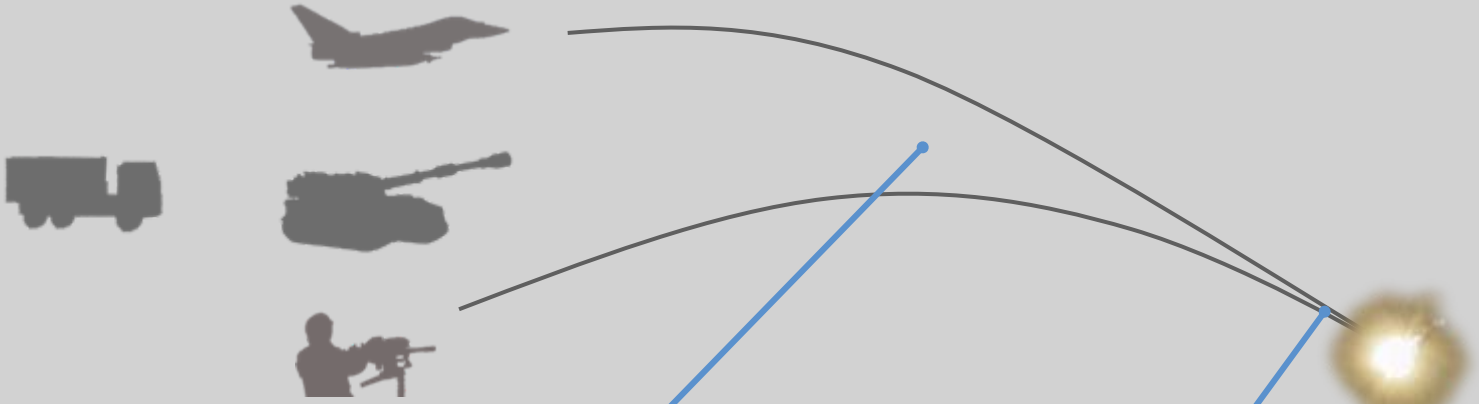


Terminal Effect: Conventional requirements



Terminal Effect: New operational requirements

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Terminal Effect Adjustment

"Smart Warhead"

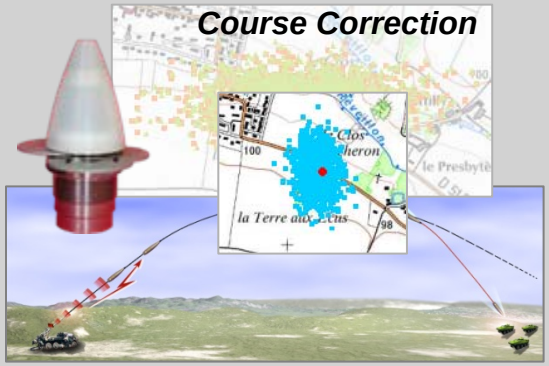
Precision Enhancement

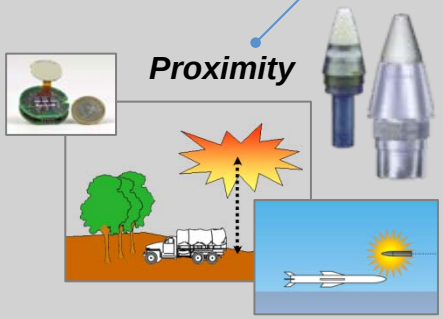
Cost Effectiveness

Collateral Damage Reduction

Logistic Footprint Reduction

Effect Optimization / Target Detection









Common Needs

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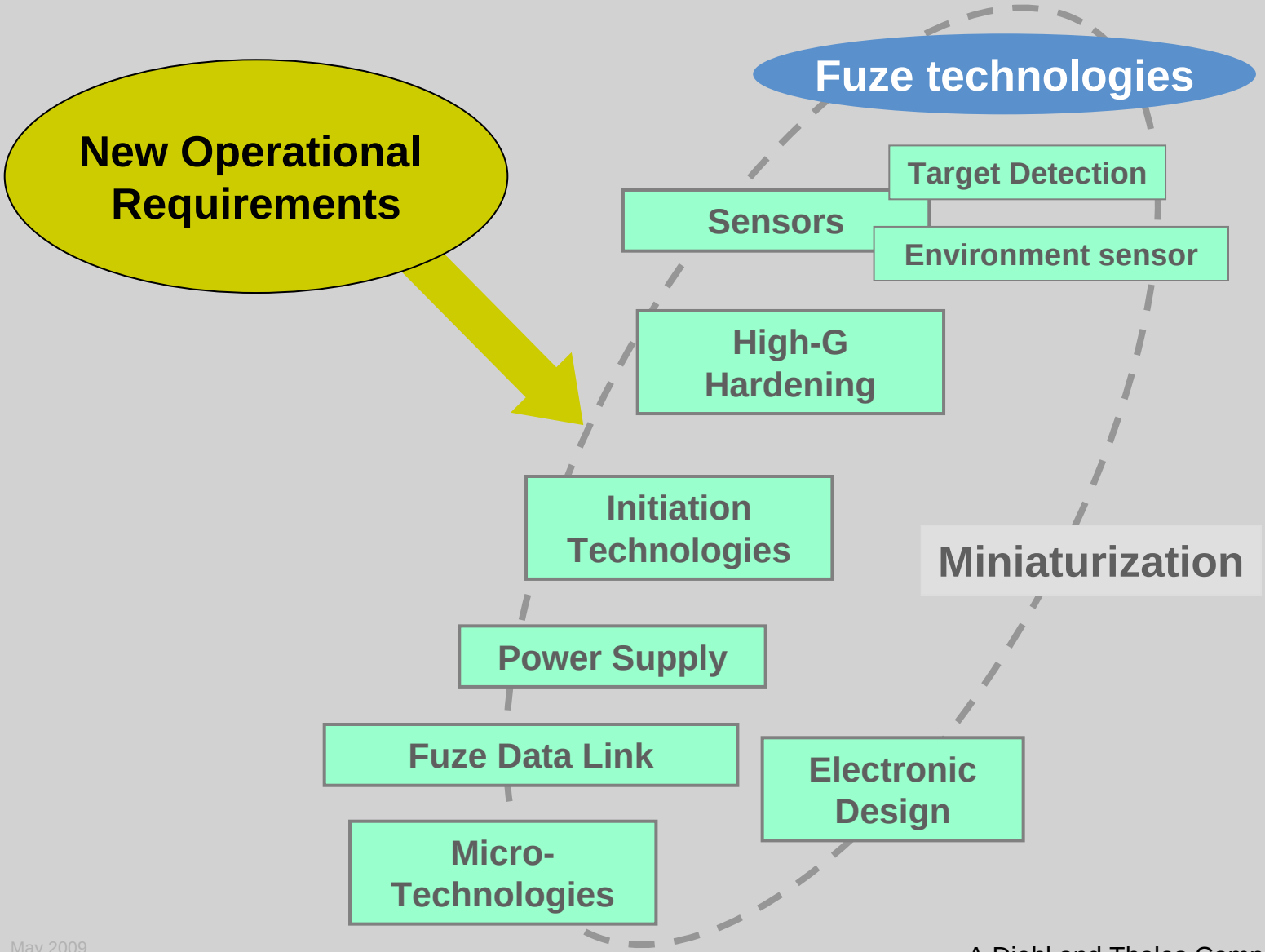
- The new needs and requirements applies to all arms:



The fuzes dedicated to the various applications can <u>share</u> the same technologies and technical solutions

Main Technical Challenges

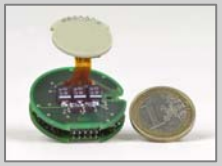
JUNGHANS microtec



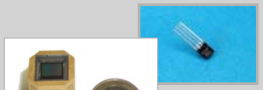
Sensors – Target detection

- More information on targets, for better accuracy and discrimination
  - Better discrimination in disturbed environment: clutter, jamming
- Compliant with fuze applications
  - Small, low energy: have to be integrated with other functions. More critical in small fuzes and smart fuzes
  - Low cost, G-hardened
- Advanced signal processing

Proximity Sensors



Radar Sensor / FMCW



IR, Magnetic, Acoustic, Sensors



Impact Sensor



Precision Accelerometers





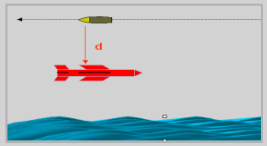
MEMS Sensors

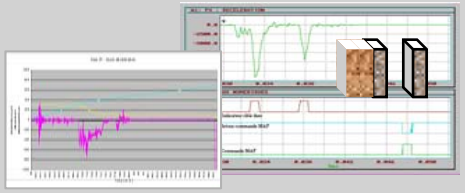
Low Cost Precision Accelerometers

Signal processing

Algorithmes

DSP, CPLD





Sensors – Target Detection

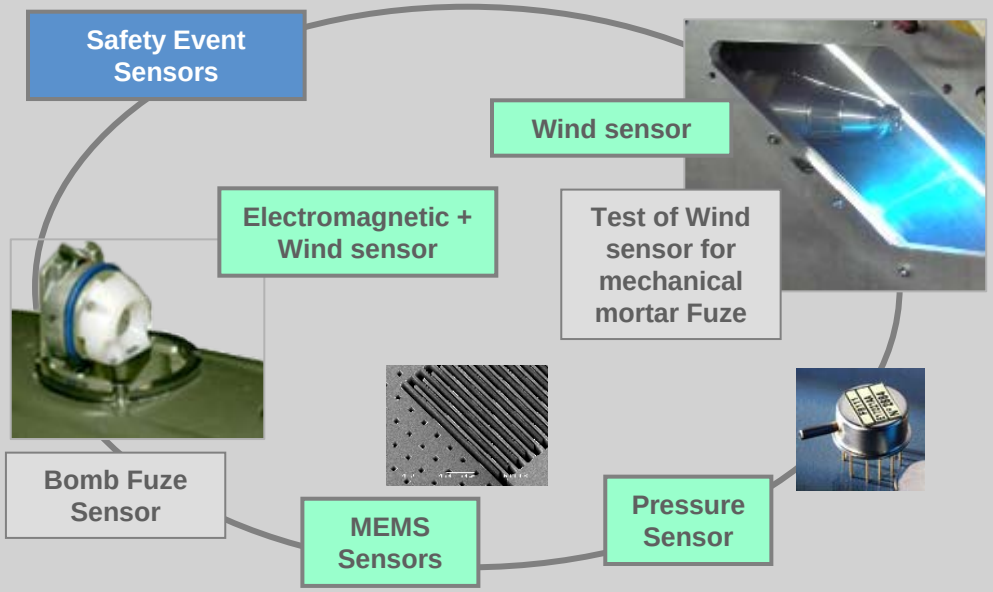
JUNGHANS microtec

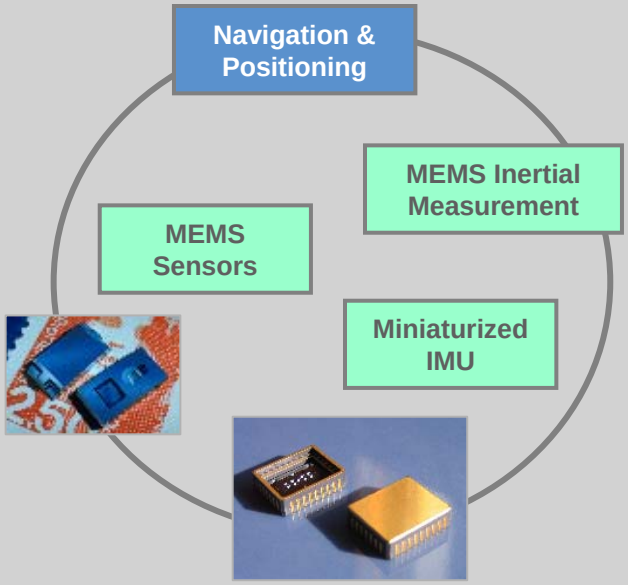


Video

Sensors – Environment Sensors

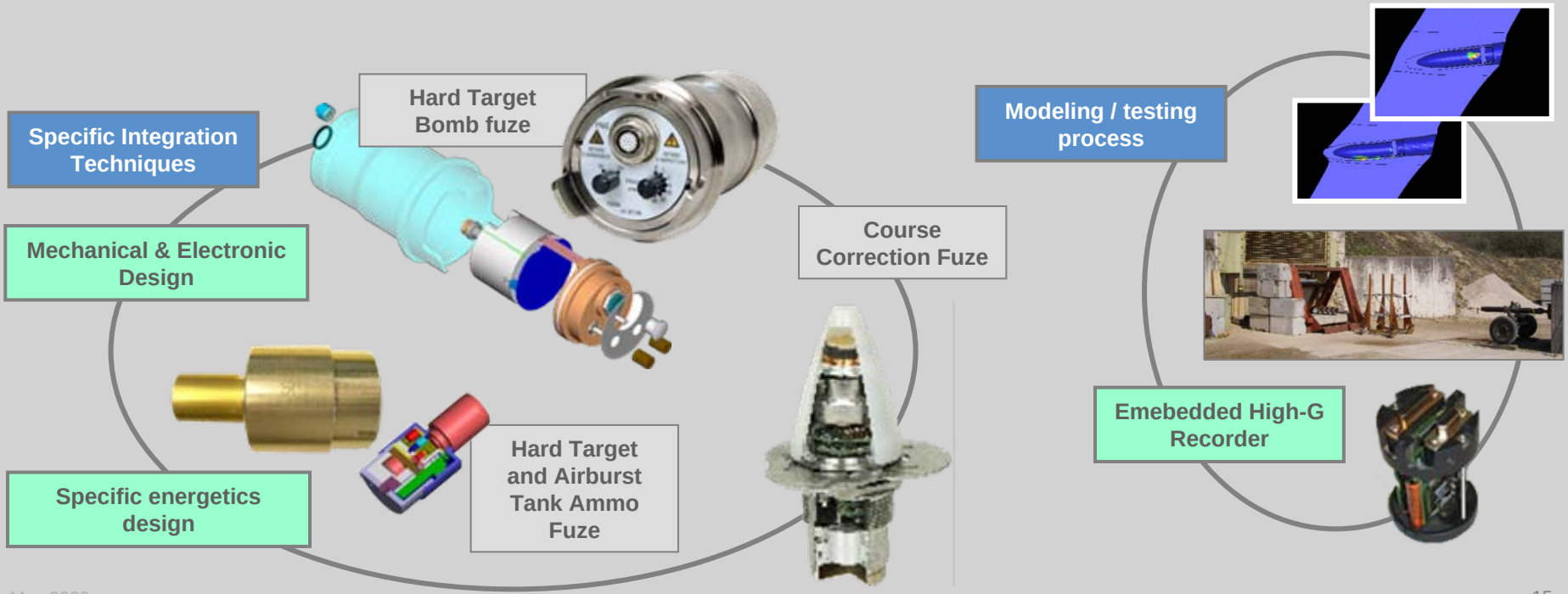
- Mechanical or electronic sensors
- Single safety event sensors
- or, accurate positioning sensors & multi-sensors, for trajectory control
- Low cost, small size, G-hardened
- Electronics safety architecture design





High-G Hardening

- Resistance to stress generated by modern weapon systems
- Hard target penetration and post-impact processing: Now often required, for all type of weapons and munitions
- Integration of more complex systems: Now necessary for smart fuzes. Use of devices not initially designed for munitions severe environments (navigation system, sensor, actuators)



High-G Hardening

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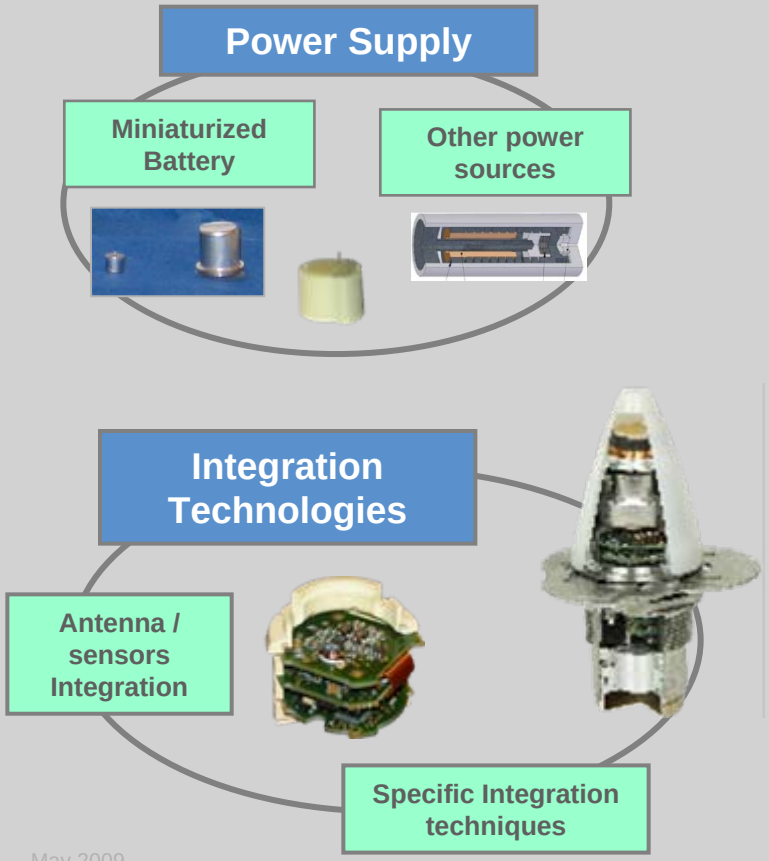
Video

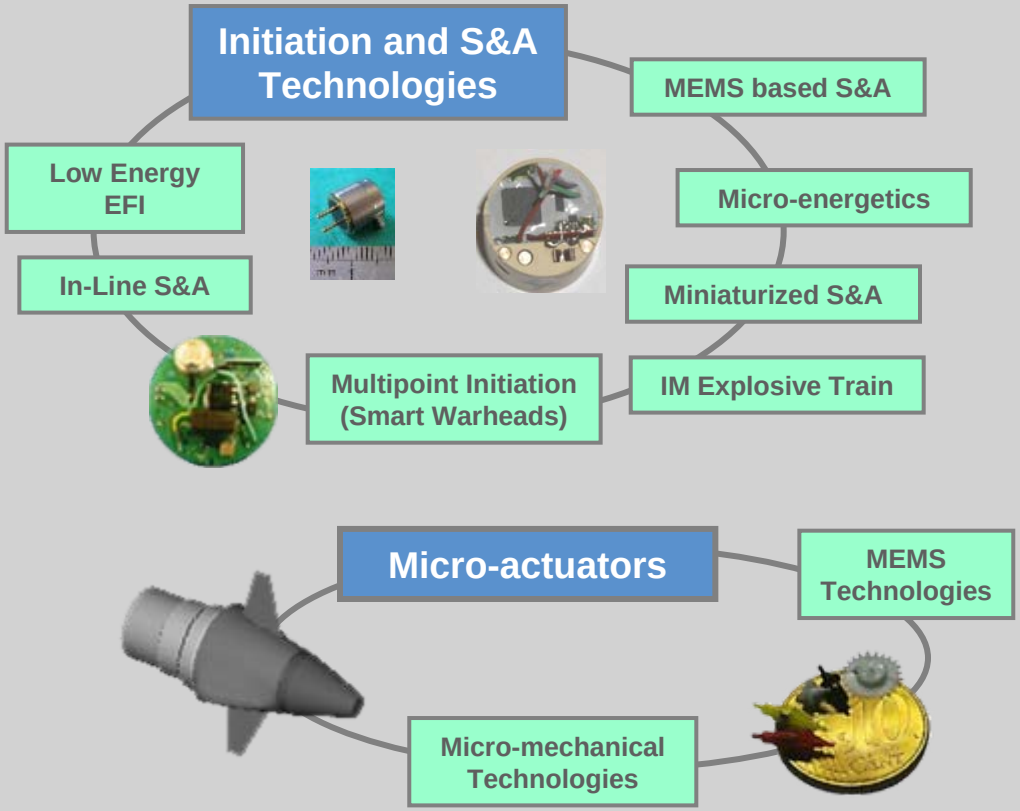


Miniaturization

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- General requirement, essential for designing new generation of fuzes
- Main stakes : Small caliber fuzes and Smart fuzes: Advanced multifunctions fuzes and 1D or 2D Course Correction fuzes

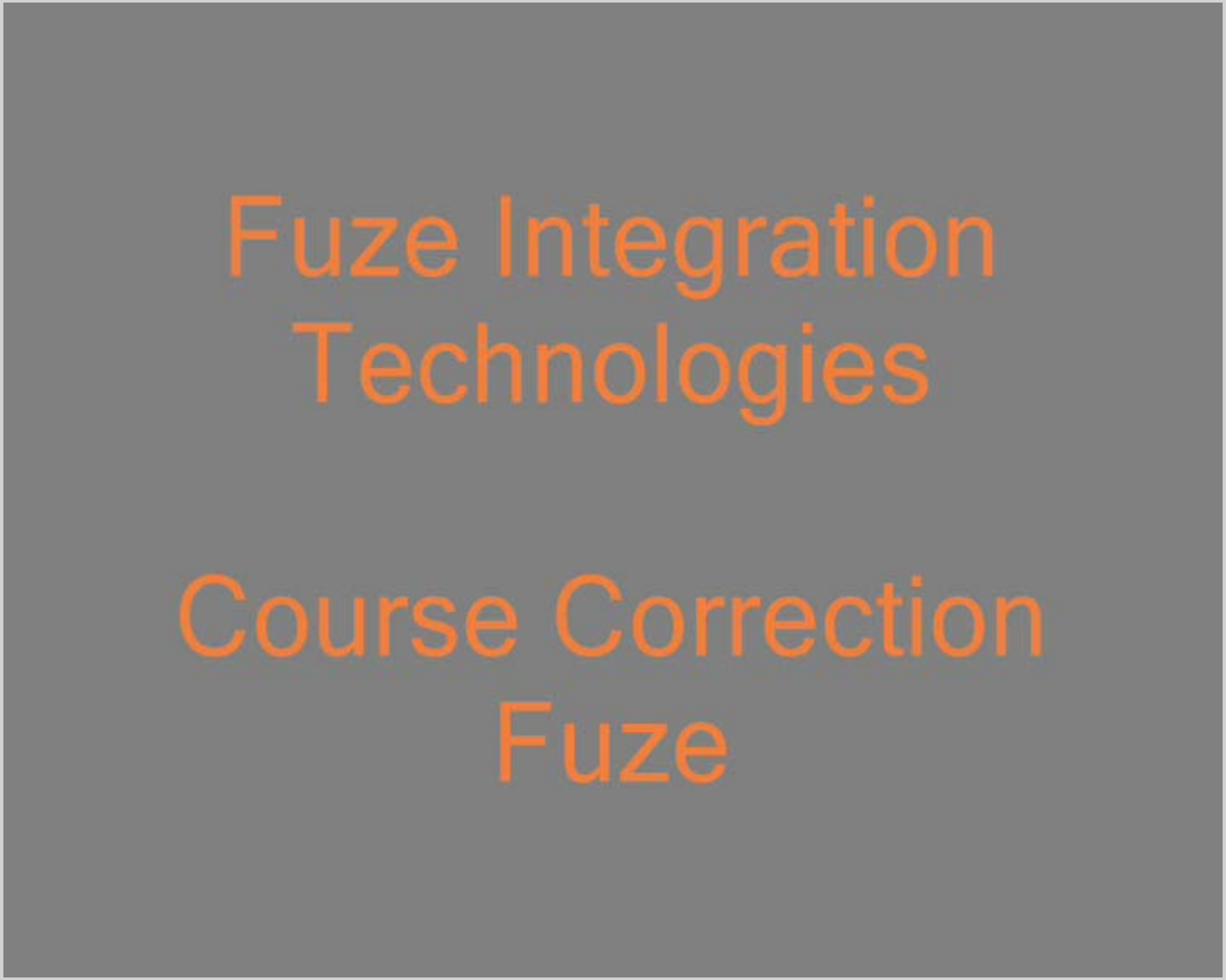




Fuze Integration Technologies

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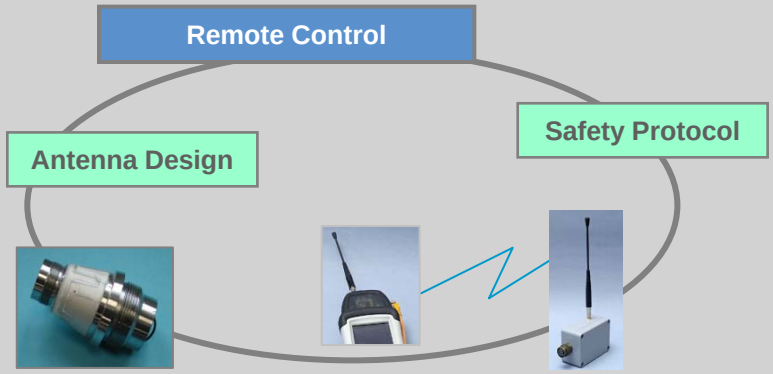
Video

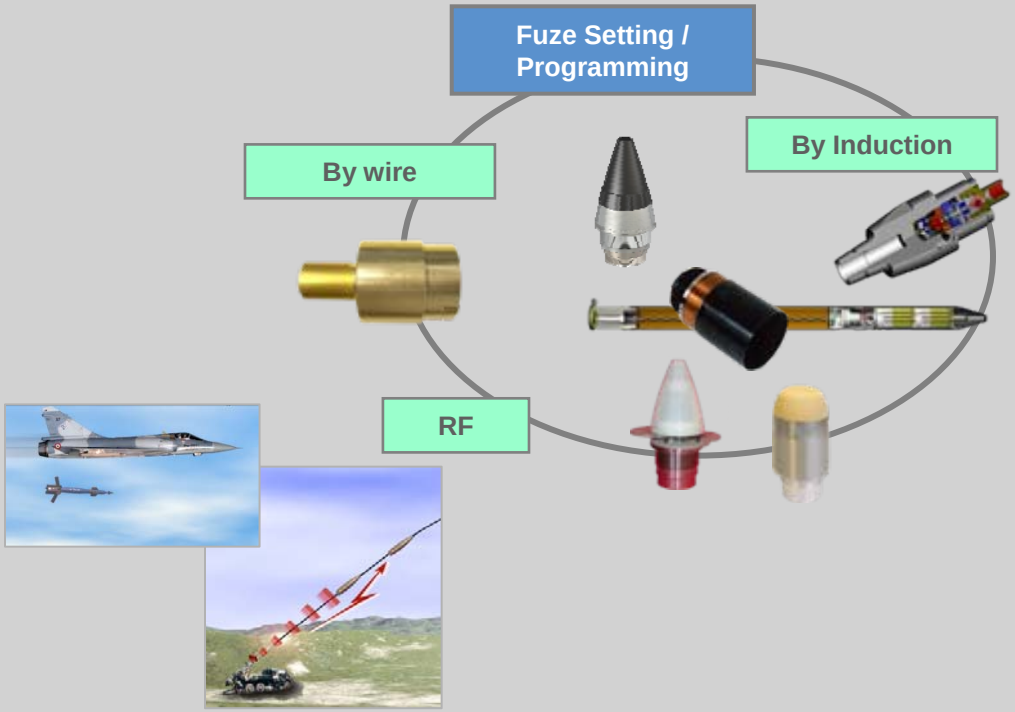


Fuze Data Link

- From simple fuze setting …

  … to the full control of fuze status during its active phase, up to the target
- More and more parameters to program in smart fuzes
- Safety and security management in all communication phases
- Wireless solutions, High rate
- Electronic safety design





Fuze Technology Developments - Trends

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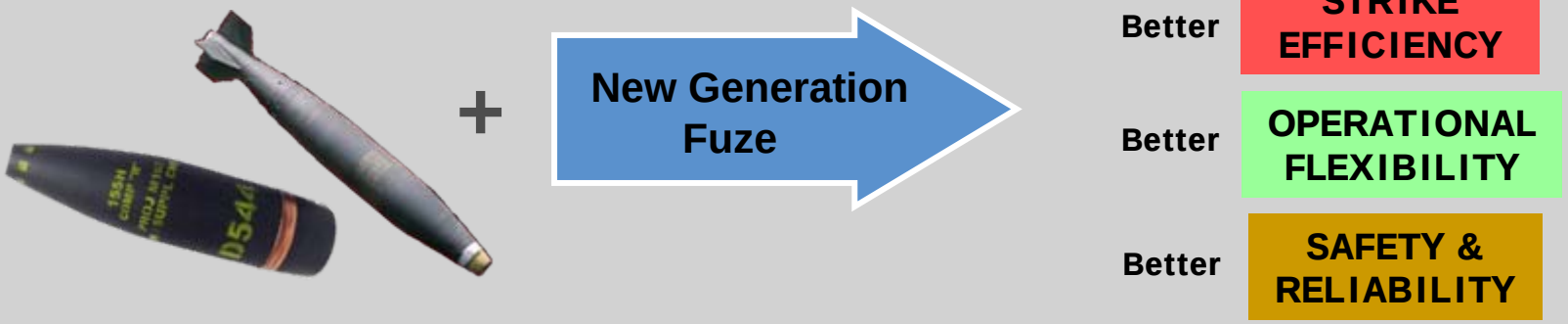
- Different categories

COTS component	" Hardened" COTS component	Dedicated component based on commercial technology	Specific technology or component development
Basic electronics Processors …	Environment sensor Specific components …	MEMS sensor Micro-technologies Specific electronic components …	Specific energetics Power supply Target sensors …

- … and always: low cost / small size / low power
- The modern fuze is a mix and concentrate of technologies which have to live together in a very small volume and under severe conditions.
- Expected technological breakthroughs in the next future should provide a significant step forward to real fuze "intelligence"
- The various munitions, for all type of weapons, will share similar technology and component developments

Conclusion

- New generation and next generation fuzes will provide maximum advantage for the warfighter



- The fuze designer / producer has a key role in the future munitions performances
- Thanks to its technological leadership **JUNGHANS** is able to
  - Provide all warfighters with state-of-the-art, efficient and cost effective fuzing solutions
  - Take up technological challenges to provide them with next generation fuzes



Thank You

Max PERRIN
Chief Technical Officer
max.perrin@junghans-microtec.de
max.perrin@junghans-t2m.fr

Flight Controlled Mortar (FCMortar) for Precision Urban Mortar Attack (PUMA)

NDIA Fuze Conference
19-21 May 2009



Luke Steelman
Flight Controlled Mortar, Program Manager
Naval Surface Warfare Center, Dahlgren Division
Precision & Advanced Systems Branch, Code G33
(540) 653-4984 DSN 249-4984
sanford.steelman@navy.mil

David H. Lyon
Chief, Advanced Munitions Concepts Branch
U.S. Army Research Laboratory
ATTN: AMSRD-ARL-WM-BA (bldg 4600)
Aberdeen Proving Ground, MD 21005-5069

Distribution Statement A: Approved for Public Release; Distribution is Unlimited

NAVSEA WARFARE CENTERS DAHLGREN

Flight Controlled Mortar
FCMortar

- What is FCMortar?
  - Guidance Kit for 81mm HE ammunition
    - Adds precision capability to M821A1/A2 & M889A1/A2 Family of Ammunition
    - Upgrade performed at Depot level
    - Core weapon system for Precision Urban Mortar Attack (PUMA)
- Why FCMortar?
  - 81mm mortar systems currently area fire weapons
    - Can't provide fire support in confined areas/difficult access terrain
    - No precision capability
  - Brings light-weight precision capability to the company/platoon level
    - Utilized within USMC Enhanced Company Operations (ECO) framework
    - Timely, Organic Fire Support

Does not replace existing 81mm Mortar Inventory

NAVSEA WARFARE CENTERS DAHLGREN

Flight Controlled Mortar
"Difficult Terrain"

ARL

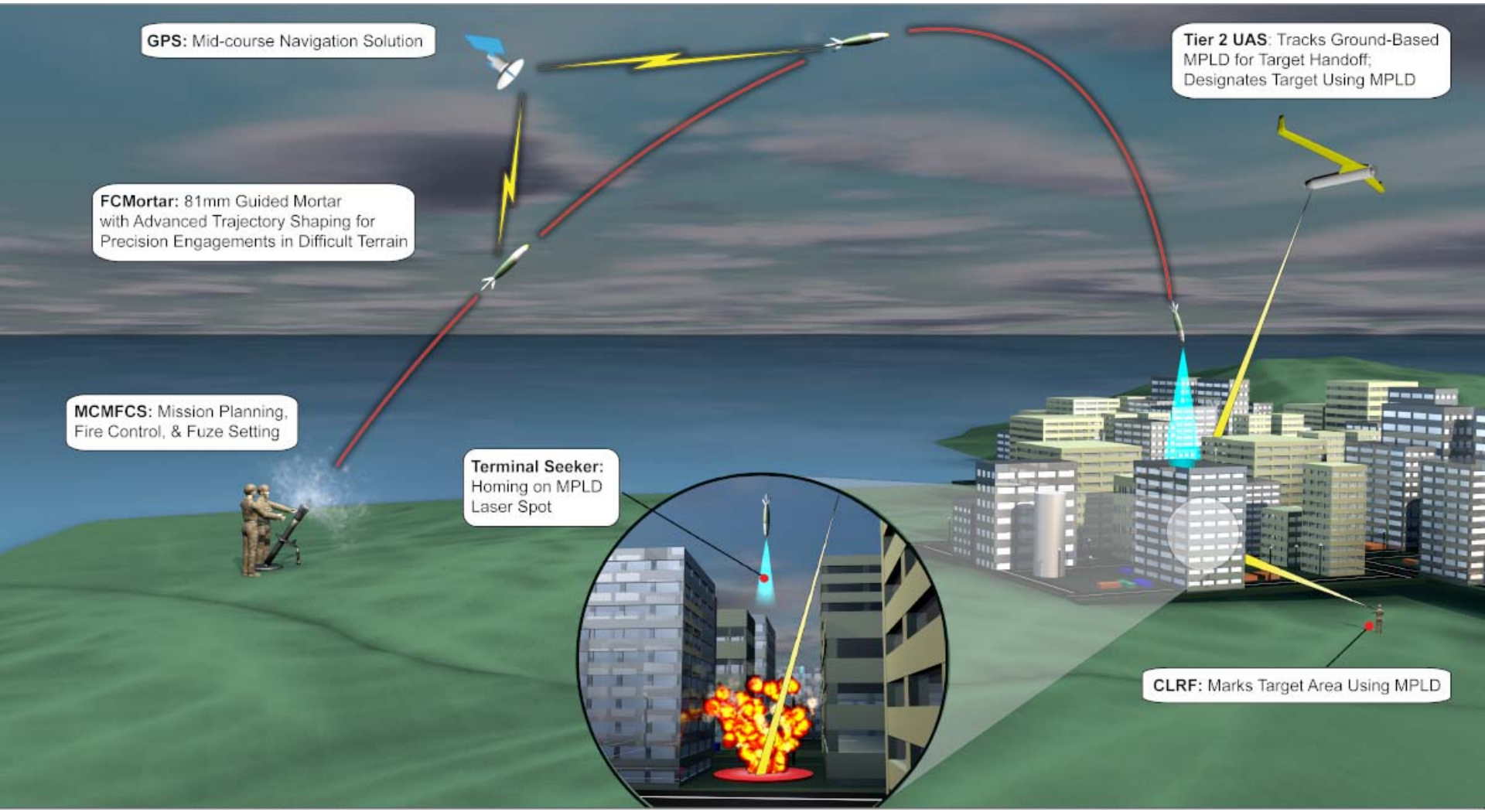




Engagements in New Terrain Types Hampered by Topology

NAVSEA WARFARE CENTERS DAHLGREN

Precision Urban Mortar Attack
PUMA



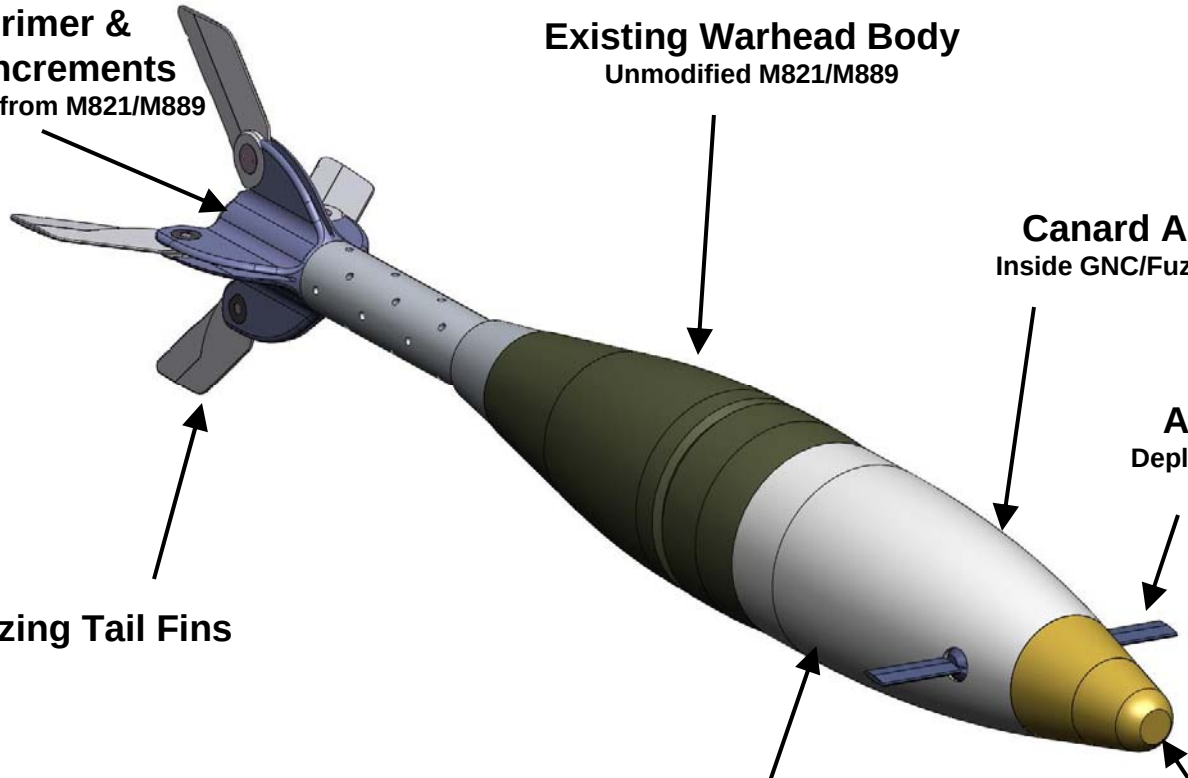
NAVSEA WARFARE CENTERS DAHLGREN

Flight Controlled Mortar
Projected Capabilities

ARL

- Precision Delivery
  - GPS & SAL
    - SAASM + Anti-Jam GPS
    - Micro-Pulse Laser Designation (MPLD) Seeker
  - Access to new/difficult terrain types
    - Urban (MOUT), Canyons, Mountains, Reverse Slope
    - Accomplished through advanced trajectory shaping techniques
- Built on existing mortar capabilities
  - Retains fuzing functions & propulsion system
  - Comparable engagement ranges
- Cost Driven solution
  - $3,200 - $5,000 AUPC

Flight Controlled Mortar
Current Design Overview



Existing Primer & Propellant Increments
Leveraged directly from M821/M889

Existing Warhead Body
Unmodified M821/M889

Canard Actuator
Inside GNC/Fuze Assembly

Articulating Canards
Deployed at Start of Guided Flight

Stabilizing Tail Fins

GPS Receiver
Mayflower C/A
GPS Receiver for Phase I

Terminal Seeker
MPLD

Flight Controlled Mortar
DoD Development Team

- Sponsor
  - Office of Naval Research, Code 30 Fires
- Principal Investigator
  - Naval Surface Warfare Center Dahlgren Division
    - Code G33 – Precision & Advanced Systems Branch
- Guidance Kit Development, Integration, & Testing
  - Army Research Laboratory, Aberdeen Proving Ground
    - Advanced Munitions Concepts Branch
- Fuzing
  - Armament Research, Development and Engineering Center (ARDEC)
    - Fuze Division, Adelphi
- Terminal Seeker Development
  - Micro-Pulse Laser Designation
    - Naval Surface Warfare Center Dahlgren Division
      - Code G31– Expeditionary Weapon Systems Branch
        - » Targeting Engagement Systems Center of Excellence (TESCE)

Flight Controlled Mortar
Program Schedule

- Phase I (FY09-11)
  - Development of system architecture
    - Sub-system development & demonstration
  - Terminal seeker technology maturation
  - GPS only guided flight & trajectory shaping demonstrations

- Phase II (FY12-14)
  - Terminal Seeker Integration
  - Guided flight & trajectory shaping demonstrations w/ Terminal Seeker
  - PUMA Demonstrations
    - End-to-end demonstration including ground & UAS designation systems
    - Intended to be as realistic as feasible
  - Transition to Acquisition

Flight Controlled Mortar
Airframe Wind Tunnel Test (WT1)

- First Demonstration Event
  - ARDEC Sub-Sonic Wind Tunnel, Picatinny Arsenal
    - 9-12 February 2009
- Validated most aerodynamic predictions
  - Supports simulations showing vertical approach & range extension capabilities
  - Minor design change needed to enhance static margin
    - Tail-kit redesign completed





NAVSEA WARFARE CENTERS DAHLGREN

Flight Controlled Mortar
Fuze Replacement

ARL

- Forward section of guidance kit replaces existing M734/935 mortar fuzes
  - Maintains existing fuzing capability
    - PD, PD Delay, HOB
    - Additional modes possible
      - Time, Point-in-Space, etc…
  - Utilizes existing production components where feasible
  - New components currently being investigated for applicability
    - HOB antenna, 2nd Arming environment sensors, MEMS fuzing components



Flight Controlled Mortar

Summary



- Supplements existing 81mm mortar inventory with precision capability
- Allows engagement of targets in previously inaccessible terrain
- Reduces cost & creates a more mobile alternative to existing precision fire support systems
- Supports Enhanced Company Operations (ECO) Framework as part of PUMA system of systems approach

THALES NDIA-09 Briefing

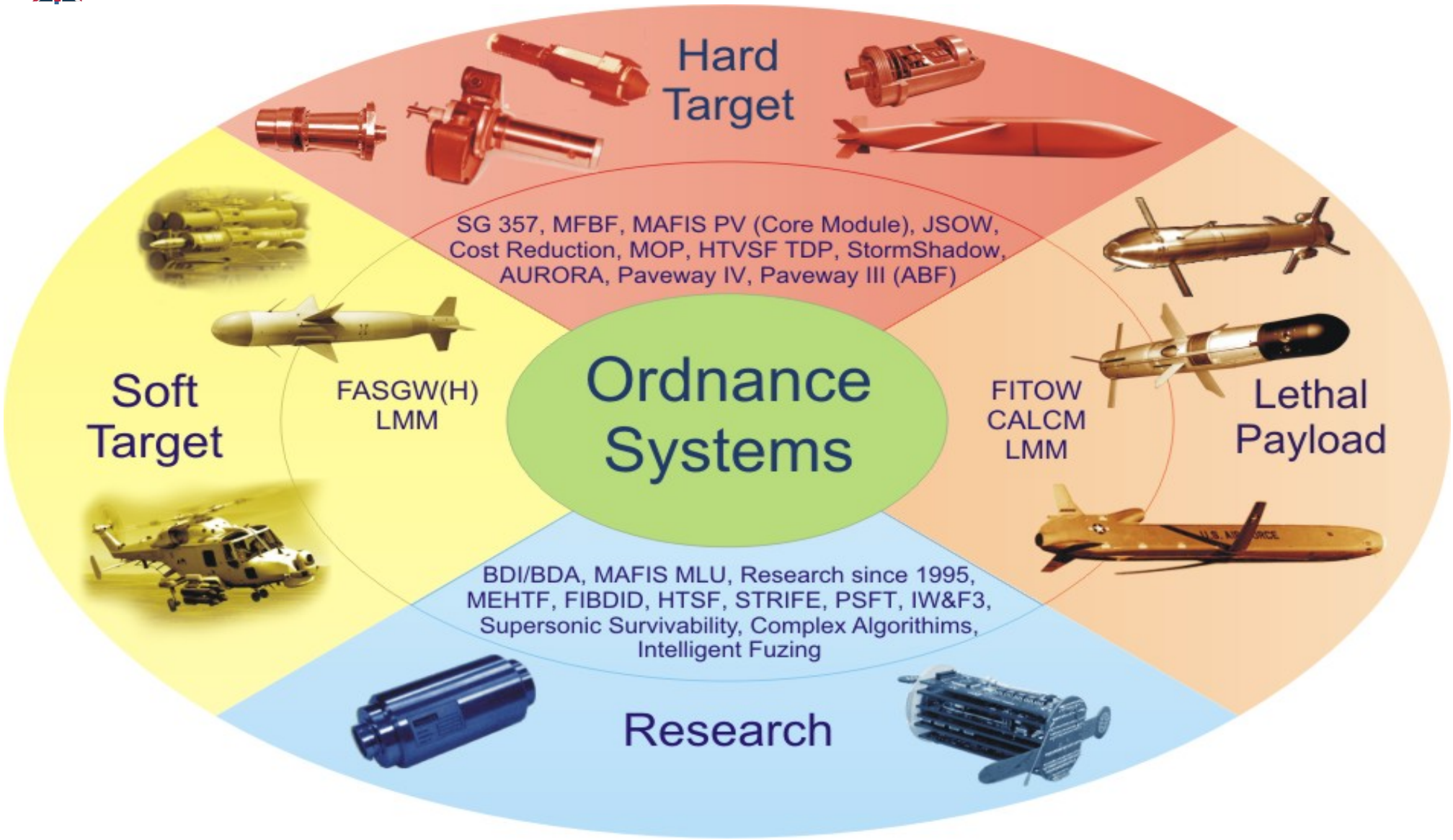


AURORA – Next Generation Fuzing System

L.J.Turner CEng MIMechE, MIET.

Head of Ordnance Systems Group

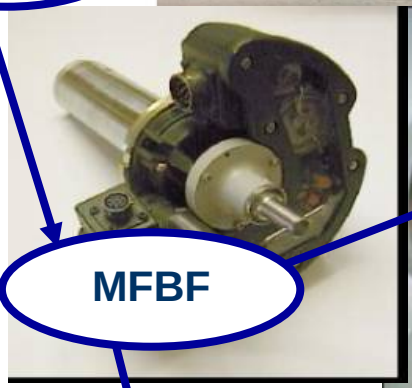
Ordnance Systems



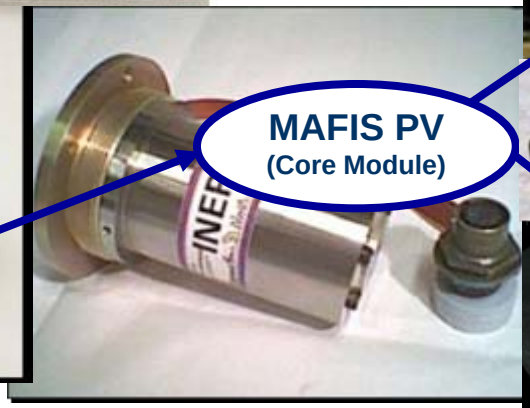
TME Ordnance Hard Target Fuzing Pedigree



SG 357



MFBF



MAFIS PV
(Core Module)



JSOW



Cost Reduction

MOP



HTVSF
JCTD



Storm
Shadow



MAFIS MLU



Intelligent Fuzing
Research since 1995



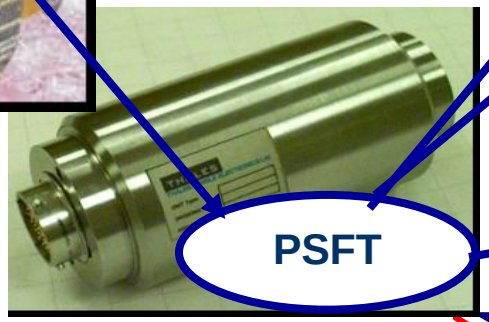
MEHTF

FIBDID

STRIFE



HTSF



PSFT



AURORA
Paveway IV

Paveway III
(ABF)

Background To Aurora Fuze

MFBF

MAFIS

JSOW

Storm Shadow

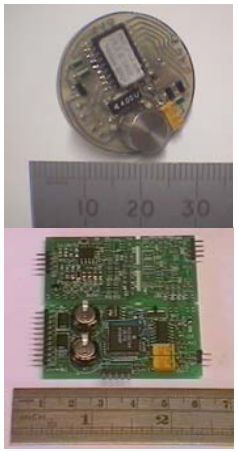
IF research since 1995

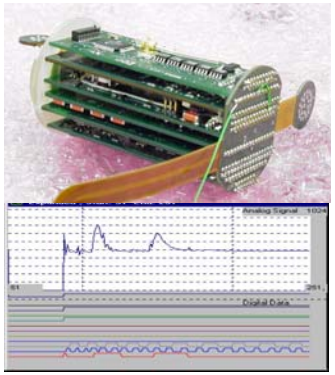
MEHTF

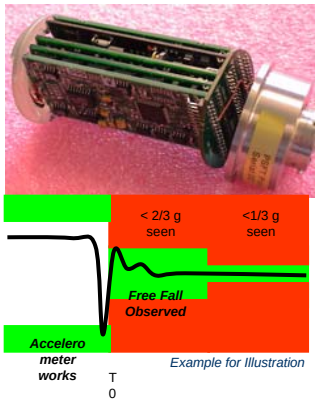
PSFT

AURORA

Paveway IV (PGB)









Aurora

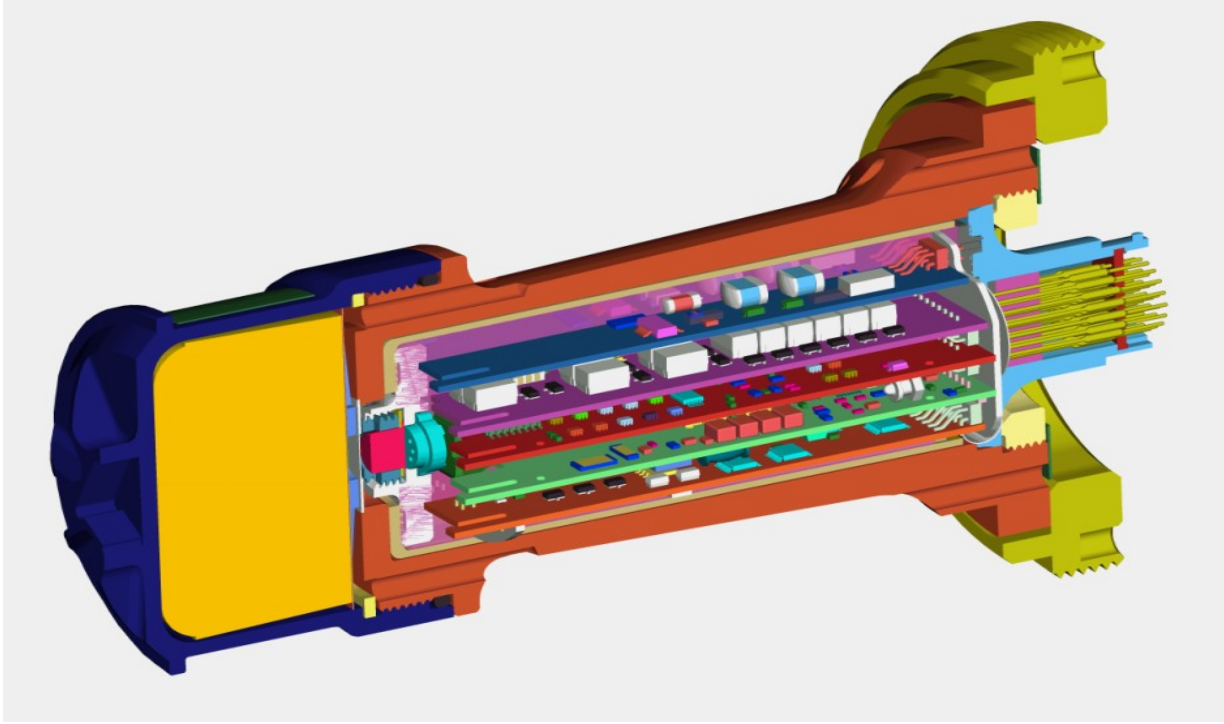
Design, Develop and Qualify fuze for Paveway IV Weapon

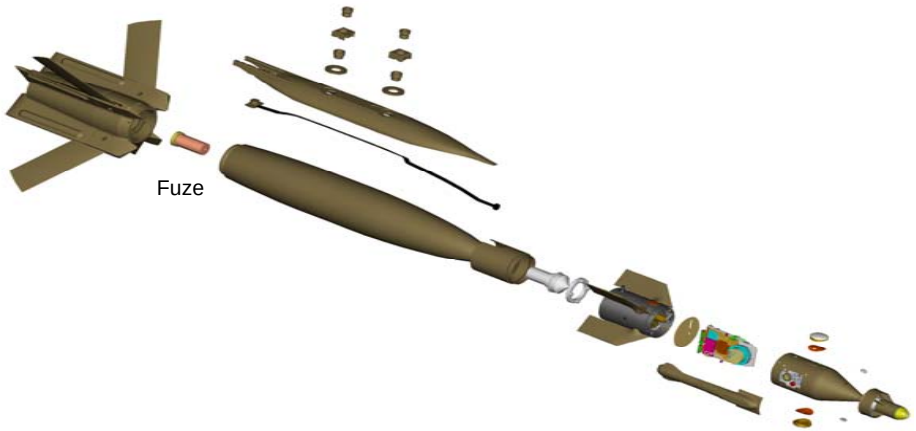
Development contract for Fuzing System in Jan 2004

Contract covers development & production

Successful qualification in early 08

In Full Rate Production





High Reliability Programmable Guided Weapon Fuze

In-Line Safety and Arming System based on MEHTF/PSFT.

Hardened, 3” Fuzing System using 2” electronics

Employs Novel Post Release Safety Environment Sensing

THALES MISSILE ELECTRONICS LIMITED

Summary of Requirements for Safety Sensors:

1st Sense the Intentional Release from the launch platform

2nd Confirm Weapon has been released into the expected environment

(Operation of at least one of the independent safety features shall depend on sensing an environment after first motion in the launch cycle or on sensing a post launch environment.) STANAG 4187 & Mil-Std-1316

Safety (Probability of False ARM)

- The Post Launch Environment Signature Shall be Unique
- Cannot be generated by credible accident, in normal handling, use, deployment or be subject to a single point failure

Reliability (Probability of Detection)

- Throughout the operational flight envelope
- In line with the system requirement

Typical Sensors

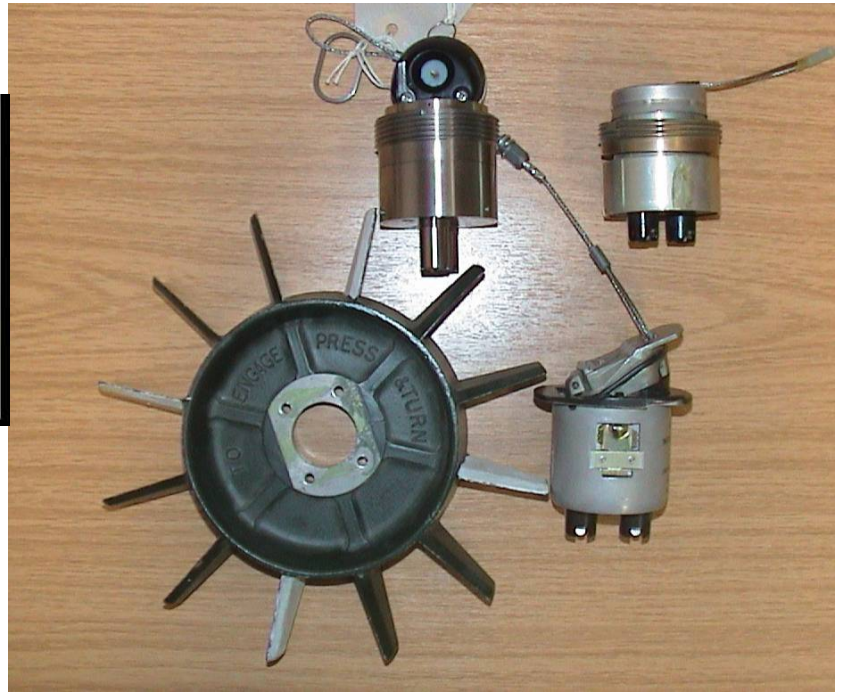


Air Flow:

Can provide a power source

But: senses an environment that is not totally unique to either “First Motion” or “Post Launch” (mainly “lanyard pulled”)

Also issues with high altitude, thin air, damage, drag etc.



Retardation sensing:

Parachute operation detection



Air pressure:

Pitot (air speed)

Motor operating

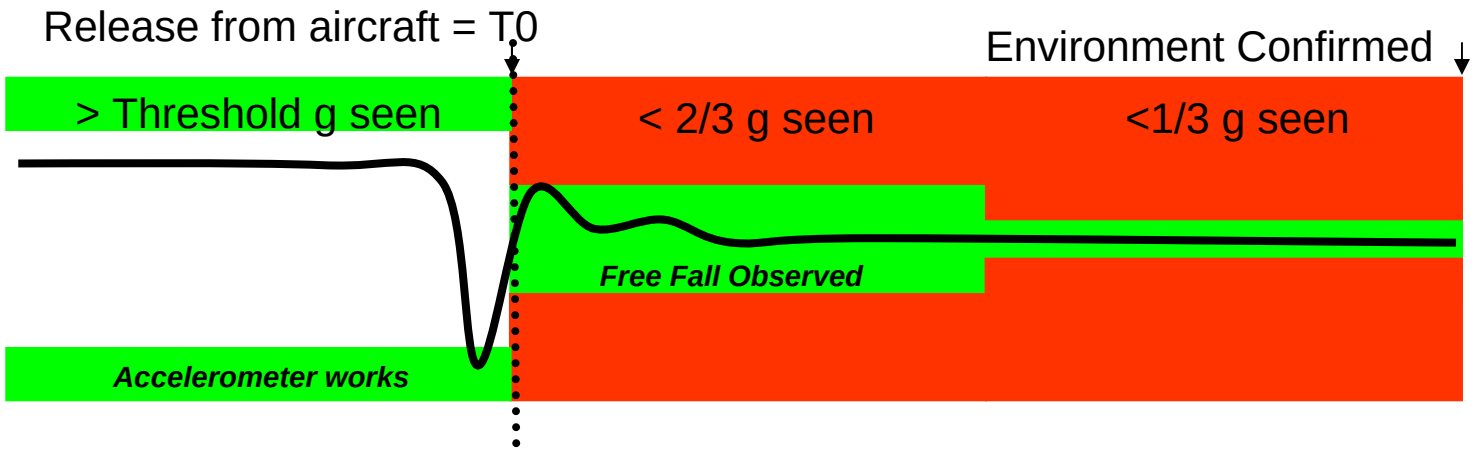




Weapon Arming Manoeuvre (WAM)

➔PSFT introduced crossed axis MEMS Accelerometers and Processor to sense Post Release Environment





EXAMPLE : Internal Fuze Accelerometers monitor unique launch “g” followed by post launch zero “g” to confirm post launch environment

Implementation

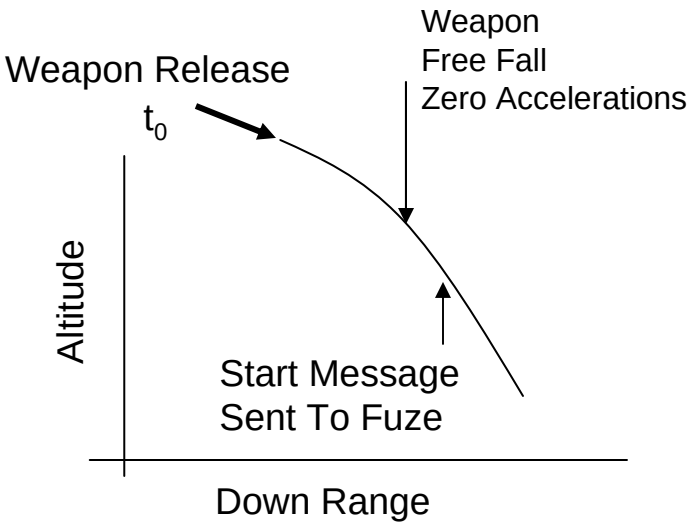
- ➔Allow weapon to determine start point
- ➔Two stage manoeuvre
  - Enable Arming
- ➔Late Arm signal
  - Weapon Armed



BWAD Requirements

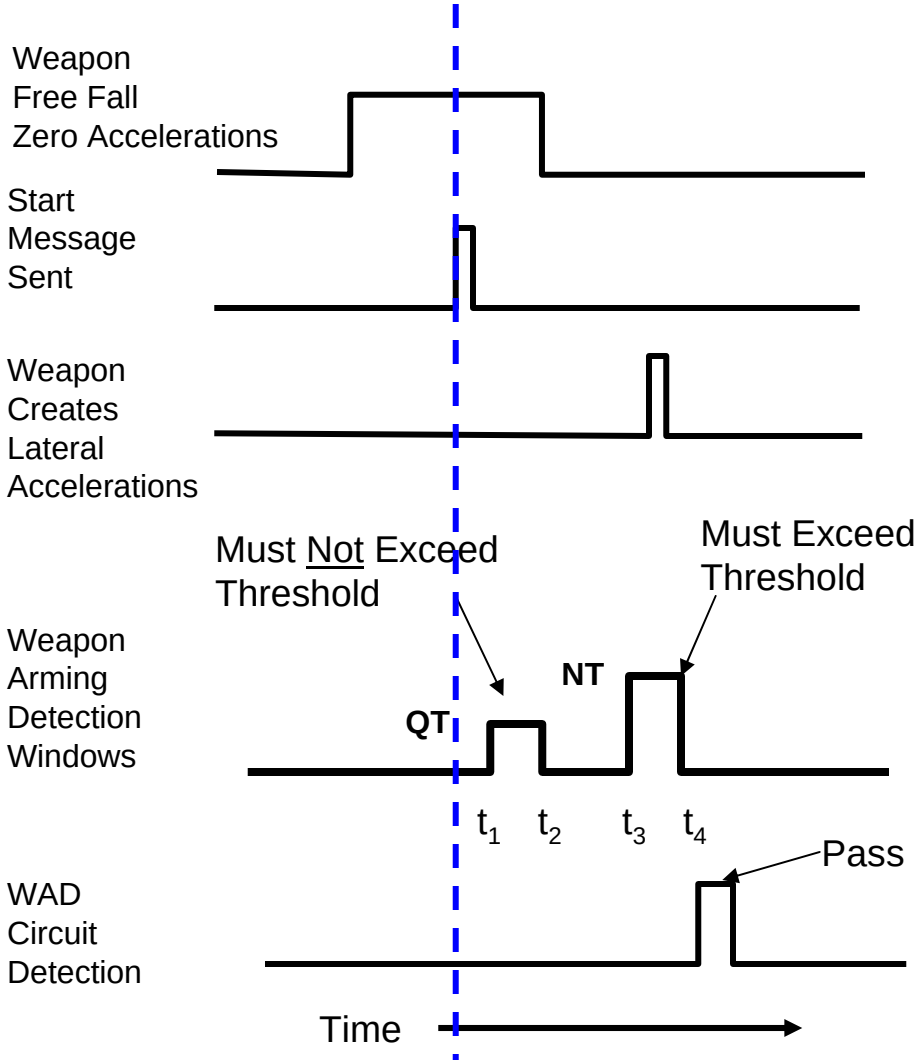
- The Ballistic Weapon Arming Detector (BWAD) will detect two events:
  - ➔ The presence of ballistic flight called the “quiet zone”.
  - ➔ A manoeuvre at a precise time following the “quiet zone”.
- Ballistic WAD Threshold and Timing:
  - ➔ Upon receipt of the start command from the weapon, the Fuze will enable the circuitry to validate the weapon motion during quiet zone and manoeuvre.
  - ➔ Two different acceleration thresholds (g levels) are defined; one for each event.
  - ➔ During the quiet zone the g levels must remain below the acceleration threshold.
  - ➔ Following the quiet zone, the g level must cross the acceleration threshold during the manoeuvre
- A Dual Axis Accelerometer is used to measure the “g” levels as the manoeuvre is performed
- Accelerations due to Vibration on the Wing Encountered During Training and Tactical Missions and due to vibration encountered during transport or assembly not be mistaken for the WAM

Ballistic Weapon Arming Detection (BWAD) Description



BWAD Variables

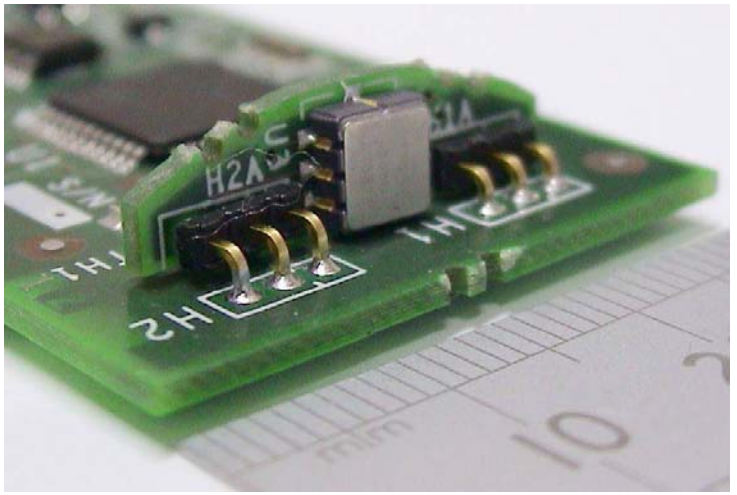
Quiet Zone Threshold	QT
Noise Zone Threshold	NT
Quiet Zone Witness Window Open Time	t_1
Quiet Zone Witness Window Close Time	t_2
Noise Zone Witness Window Open Time	t_3
Noise Zone Witness Window Close Time	t_4



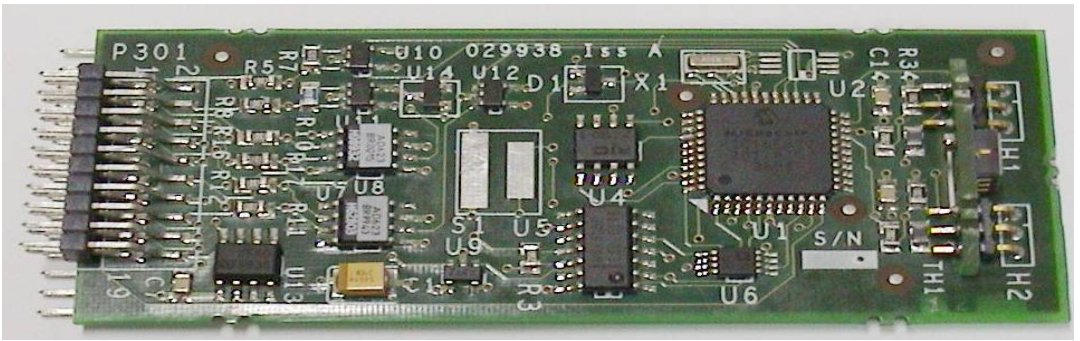
THALES
THALES MISSILE ELECTRONICS LIMITED

Advantages:

- Unique second environment
- Manoeuvre is at commanded time:
  - ➔When convenient to weapon
  - ➔Can be set to specific flight parameters
  - ➔Expands release envelope
- Simple in operation
  - ➔All "Hardware" checking logic
  - ➔No (Safety Critical) Software







Analyse and Prove Safety & Reliability performance

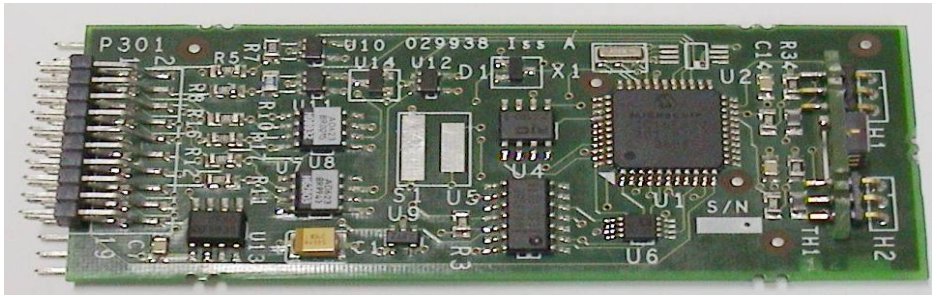
- Develop a model of the sensor and circuit

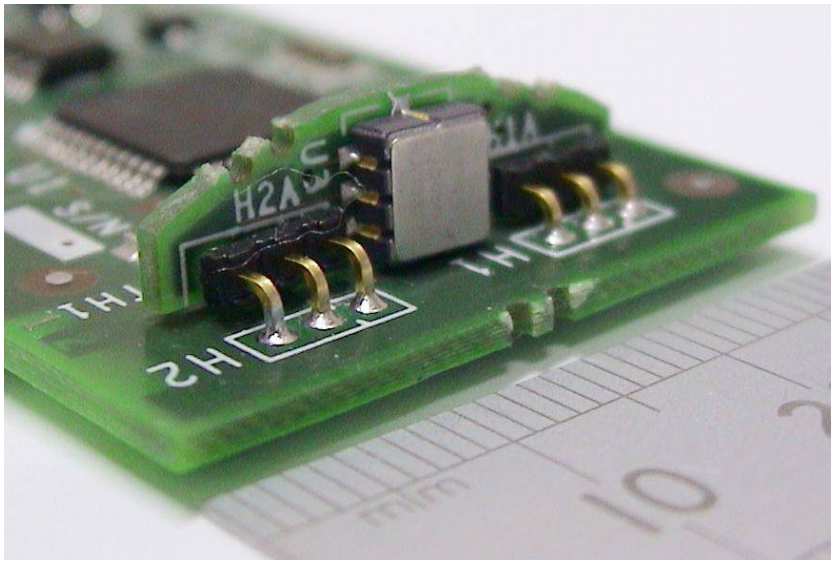
- Validate performance over the spread of component tolerances and temperatures against the actual aircraft & credible accident scenario's

- Use actual recorded data from aircraft
- Generate data for credible accidents
- Validate model against hardware in simulated environment

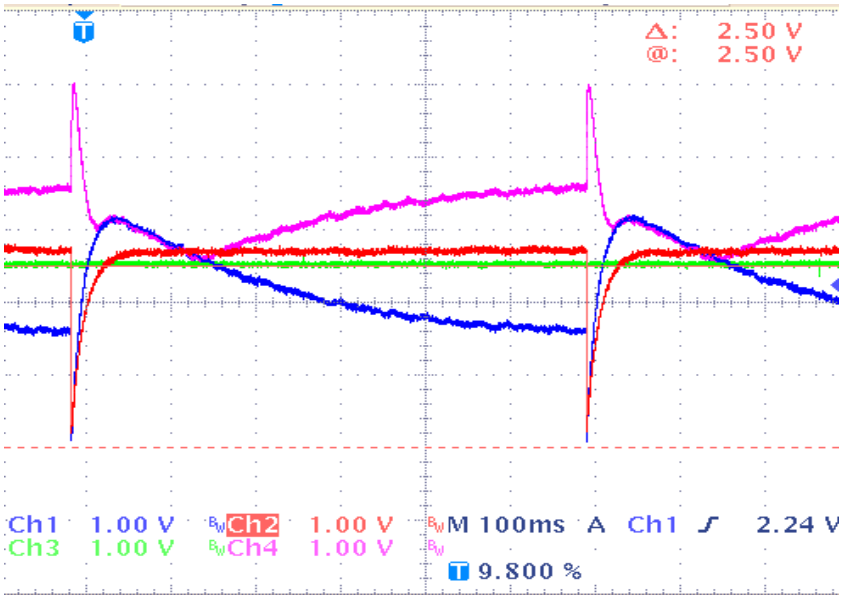
Model of the sensor and circuit

- Include Sensor parameters
  - ➔ Sensitivity
  - ➔ Linearity
  - ➔ Offset
  - ➔ Cross axis coupling
- Include component & circuit variability's
  - ➔ Component tolerances
  - ➔ Temperature variations
  - ➔ Noise
  - ➔ Calibration

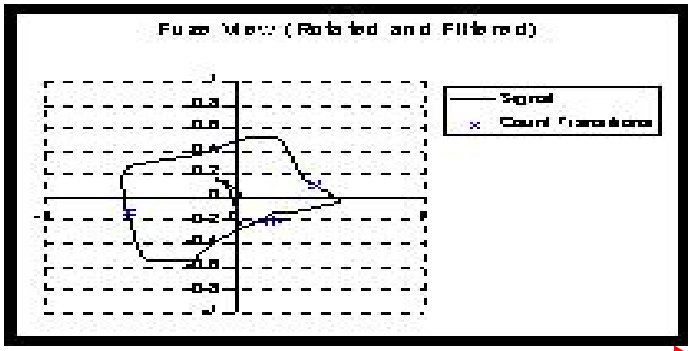




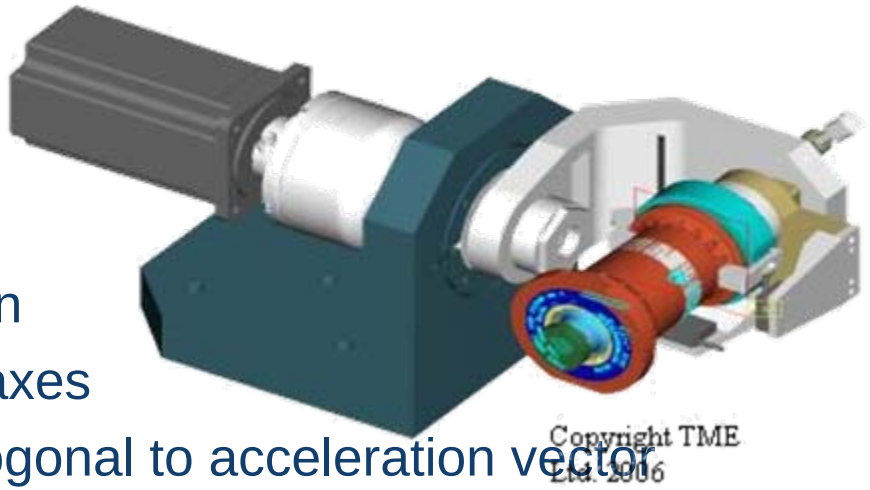
Model Benefits



- Fast Run-times
  - ➔ Enabled multiple runs
  - ➔ Good statistical analysis
- GUI front end – easy to use
- Parameters can be tuned in real time
- Enabled understanding of design and its limitations
- Enabled difficult trajectories to be easily identified and investigated
- Allowed performance of intent to be assessed without circuit being implemented



Centrifuge testing of assembly



- Centrifuge can simulate the actual weapon environments
- Two axis positioner allows acceleration produced to be vectored into difference axes
- Aligning fuze's two sensing axes orthogonal to acceleration vector enables the fuze to detect zero "g"
- Dynamic testing with Start command" followed by vectored acceleration allows representative BWAM to be applied to fuze
- Aircraft type data can also be applied. Selection of data close to the decision threshold achievable
- Incorrect inputs to prove no arming of system

Proved BWAD performance - Safe & Suitable for service

Aurora accepted into UK service

- DOC trials at China Lake

Paveway IV deployed with UK Armed Forces

Successfully fired in combat

- Against a range of hard & soft targets









THALES NDIA-09 Briefing



AURORA – Next Generation Fuzing System

L.J.Turner CEng MIMechE, MIET.

Head of Ordnance Systems Group



NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

53rd ANNUAL FUZE CONFERENCE

"Next Generation Fuzing - Maximum Advantage for the Warfighter"

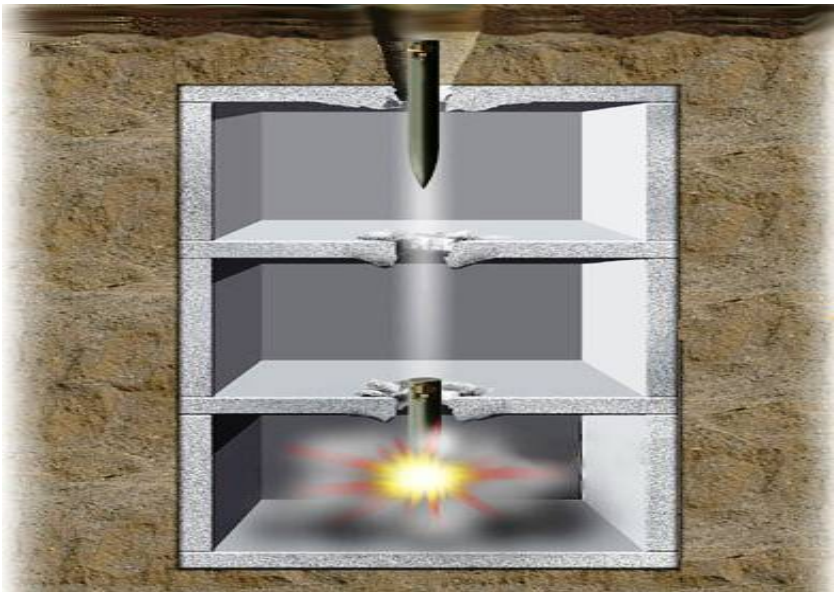
Joint Programmable Fuze Emulation



2Lt Jack Wiese
Project Engineer
Hard Target Void Sensing Fuze
679 Armament Systems Squadron
Eglin AFB, FL

Purpose

- Discuss the Hard Target Void Sensing Fuze's (HTVSF) use of emulating the Serial Data Interface of the Joint Programmable Fuze (JPF)



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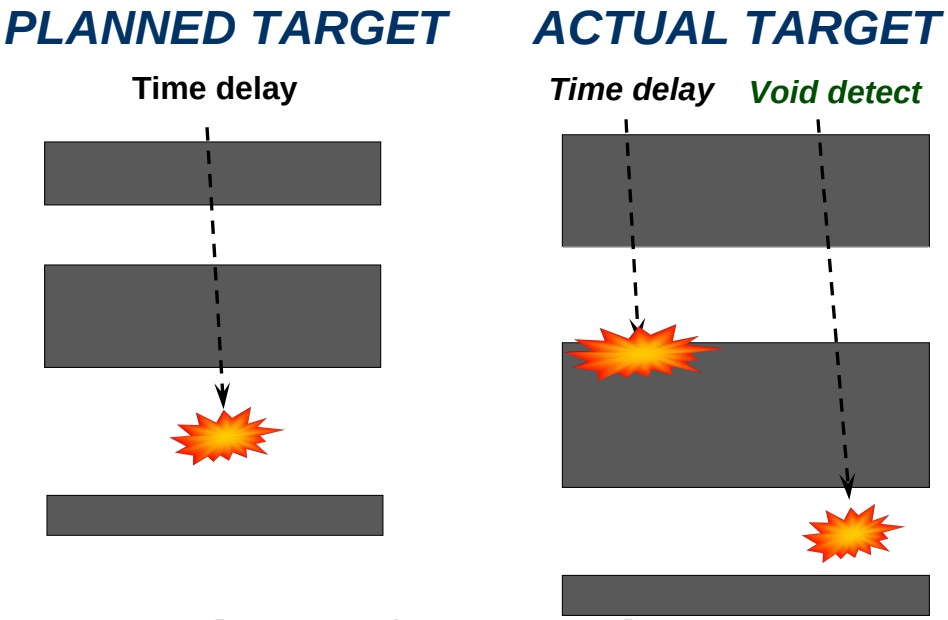
Outline

- Overview of HTVSF JCTD
- New Serial Data Interface (SDI) Issues
- HTVSF Solution to new SDI Issues
- Description of JPF Emulation Method
- Issues/Concerns Found
- Full Functionality
- Summary

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Need for a Void Sensing Fuze

- **Inability to effectively attack high value hard and deeply buried targets (HDBTs)**



- **Contributing factors**
  - **Target characterization uncertainty – fuze settings frequently ineffective against mission space**
  - **Low fuze reliability at long time delays**

Solution: A reliable, survivable fuze that detonates the warhead in the desired location

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Overview of HTVSF JCTD

- Basic Attributes of HTVSF
  - Programmable from aircraft cockpit
  - Detect more than one void and detonate in desired void
    - > 50% of warhead in void space
    - Operate with void sensing as primary mode with back-up time delay
  - Function after time delay of instantaneous to 255 ms (programmable in 1ms increments)
  - Survive 5K-15K PSI reinforced concrete (BLU-109, BLU-113).
  - Physically compatible with BLU-122

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New Serial Data Interface Issues

- Cockpit Programmability Requirements
  - Ability to select different function modes
    - Void mode and Time Delay Mode
  - Ability to select void count
  - Ability to select 256 time delay options
  - Selectable back-up timer in void mode.
  - Selectable Arm times: Arm(min) to 30 seconds in 1 second increments.



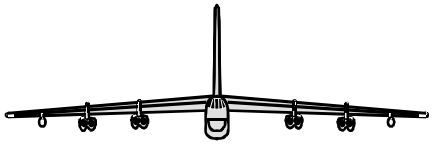
- Currently no aircraft has this capability
  - Will require Operational Flight Program (OFP) updates in at least 5 aircraft
    - Not enough funding and Warfighter still needs capability ASAP

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HTVSF Solution to New SDI Issues

- JPF Emulation
  - Pretend to be a JPF
  - Warfighter gets limited capability at fraction of cost
  - Fuze will always be capable of operating in Full Functionality (all settings) or JPF Emulation Mode (limited settings)





B-52H



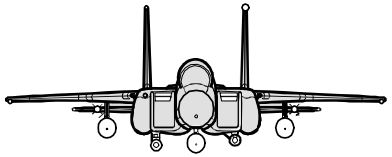
B-2A



B-1B



F-16



F-15E

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Full Functionality

- Full Functionality Interface Control Document (ICD) will be written by Boeing
- Will enable fuze to program its full range of capabilities
- Compatible with Universal Armament Interface (UAI), and MIL-STD 1760 A/C
- USN F/A-18 will only be compatible with Full Functionality Interface (OFP update required)

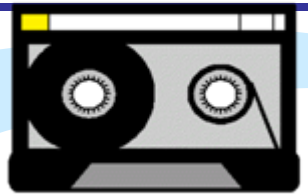
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Basic JPF Programming Scenario

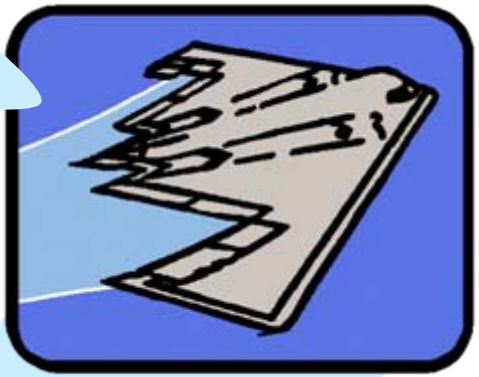


Mission Planning System

- Generate Target and Fuze Setting Information
- Settings Correlated to Planned Targets & Targets of Opportunity



Data Transferred to Aircraft Via the Data Transfer Cartridge



Fuze and Target Data are Transferred to the JDAM During Flight Via Mil-Std-1760 Interface

JDAM GCU

RS-422 UART Interface

Serial Data Microcontroller ⟷ Arming Microcontroller

FMU-152A/B Joint Programmable Fuze

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Description of JPF Emulation Method

- JPF has fewer options than are required with HTVSF
  - JPF has 16 Arm Times and 20 Delay Times
  - HTVSF Arm Requirement
    - Minimum time of flight of 20 sec to 30 sec (1 sec increments)
  - HTVSF requires 256 different delay times, approximately 10-15 void settings, and 256 back-up timer settings

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Description of JPF Emulation Method

- HTVSF will map its Arm Times to JPF's 16 available Low Drag Arm Times
- HTVSF will need to map a subset of the required Delay Time and Void Settings to JPF's 20 available Delay Times
- Subset decided by Targeting Weaponeering Assistance Cell (TWAC)
- Pilot will need translation sheet

JPF fuze settings	HTVSF
Short time delays	Short time delays
0 ms	10 ms
5 ms	15 ms
15 ms	20 ms
25 ms	25 ms
35 ms	30 ms
45 ms	45 ms
60 ms	60 ms
90 ms	75 ms
180 ms	90 ms
240 ms	105 ms
Long time delays	
15 Min	120 ms
30 Min	150 ms
45 min	180 ms
60 min	210 ms
4 hrs	255 ms
8 hrs	Void 1--60 ms
12 hrs	Void 2--60 ms
16 hrs	Void 3--75 ms
20 hrs	Void 4--90 ms
24 hrs	Void 5--120 ms

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JPF Fuze Status Data Table

Byte Number	Contains	Values
00	Checksum Result	Not Done, Passed Type 1 or Type 2, Failed
01	Low Drag Arm Time	Binary Pattern
02	High Drag Arm Time	Binary Pattern
03	Delay Time	Binary Pattern
04 and 05	Control Word 1 & 2	Echoes Back Modes and Settings Used by Arming Controller
06	Selected Power	Echoes Back Mode
07 thru 09	Post Arm Data	Bit Pattern Sent to Delay Module
10	Arm Status Word	Armed or Not Armed
11	Dud Word	Retain Fuze Dud Codes
12	Time Zero Status	Detect Fuze Power Up
13	Test Fire Status	Test Function *(Factory)*
14 and 15	Reserved	FFh

Issues/Concerns Found

- Safety Concerns
  - Mapping Arm Times
  - Method to prevent Fuze from unintentionally operating in incorrect mode
    - JPF Emulation vs. Full Functionality

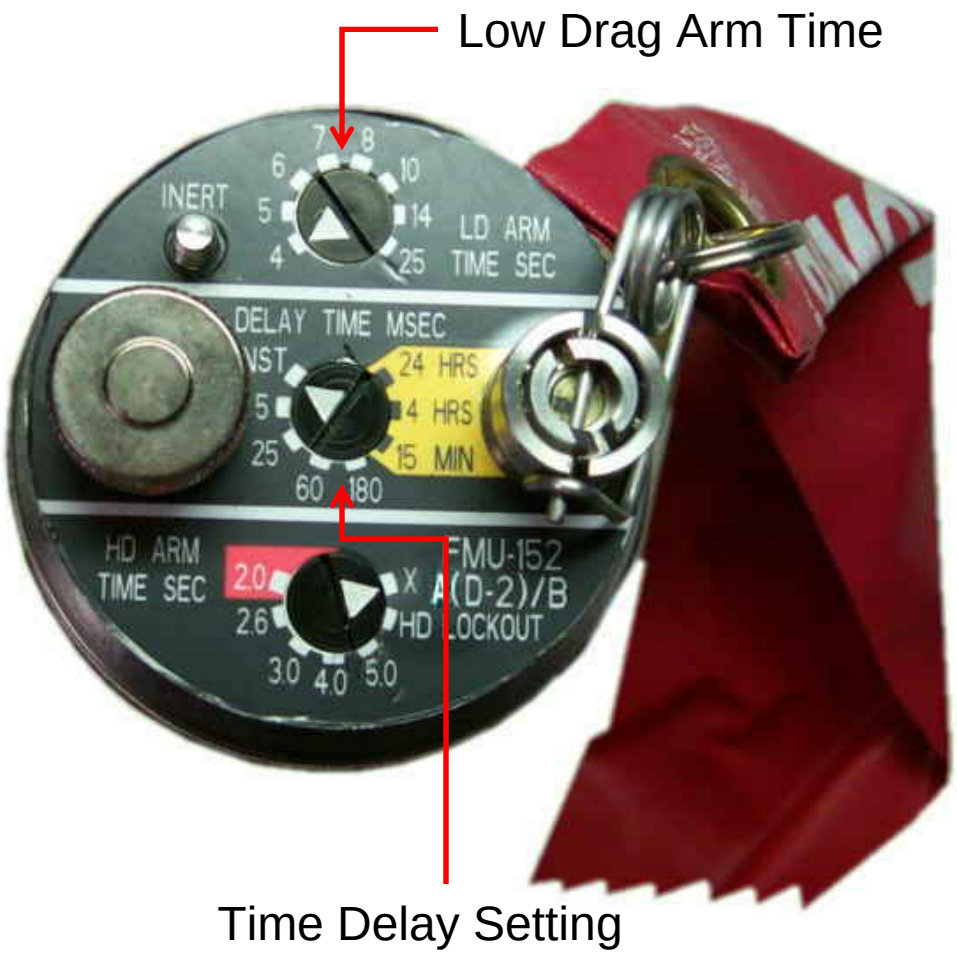
JPF Arm Time (sec)	HTVSF Interpretation (sec)
4	20
4.5	21
5	22
5.5	23
6	24
6.5	25
7	26
7.5	27
8	28
8.5	29
9	30
9.5	30
10	30
14	30
21	30
25	30

Revision A of HTVSF Annex to JDAM-JPF SDI

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JPF Default

- JPF defaults to face plate settings
- HTVSF has no face plate setting requirement
  - Hard Code Defaults
    - Arm Time: 30 sec
    - Function: Void 1, 60 ms



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1760 Control Word (Word 8)

1760 Message Word 8 (Core Interface)

bit 00	bit 02	bit 05	bit 09	bit 10	Default
Function on Impact	Function on Delay After Impact	Function on Proximity	Long Delay Enable	Go To Default	
0	0	0	0	0	Goes to Defaults (see paras 7.2.2, 7.2.3, and 7.3).
x	x	x	x	1	Goes to Defaults (see paras 7.2.2, 7.2.3, and 7.3).
1	0	0	0	0	0 milliseconds after impact. (Note 1)
x	x	x	1	0	Long Delay after Impact - Delay Time Set to Word 11 Value. (Note 2)
x	x	1	0	0	Short Delay after Proximity w/Impact Backup - Delay Time Set to Word 11 Value. (Notes 3,4)
x	1	0	0	0	Short Delay After Impact - Delay Time Set to Word 11 Value. (Note 5)

x - Don't Care

Table 10 Control Word Bits / Default Decision Table

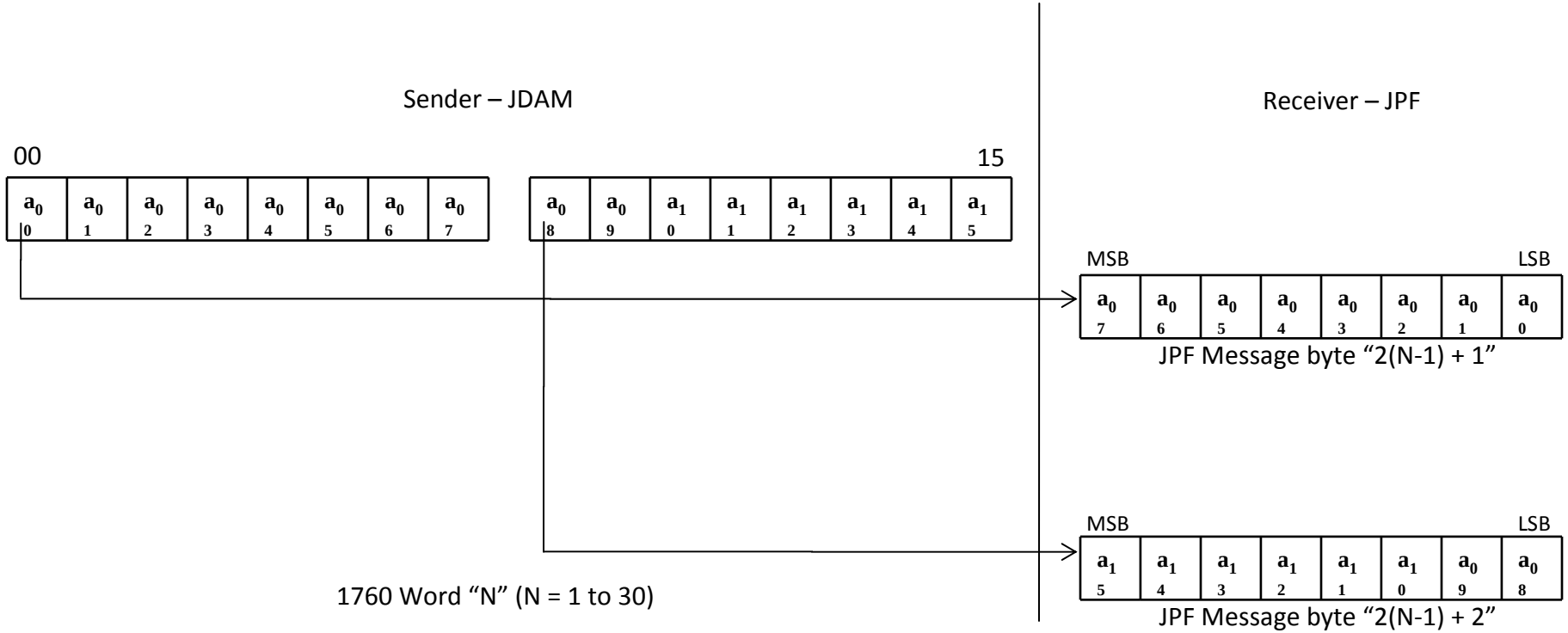
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JDAM-JPF Settings Message

- Requires fuze vendors to emulate communication protocol they did not design
- Must emulate every aspect of the interface



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Summary

- Warfighter needs cockpit programmable void sensing fuze ASAP
- Limited funding for aircraft OFP updates
- HTVSF solves problem with JPF Emulation
- UAI is the long term solution for full functionality without an OFP update

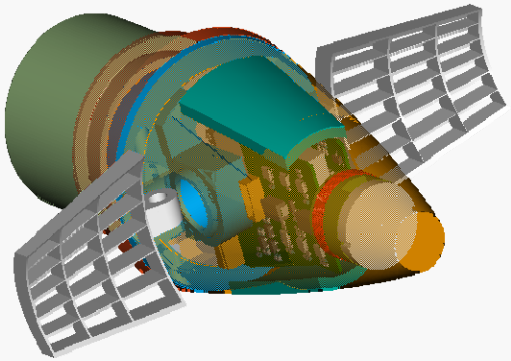
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Questions?



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GUIDANCE INTEGRATED FUZE DEMONSTRATION PROGRAM

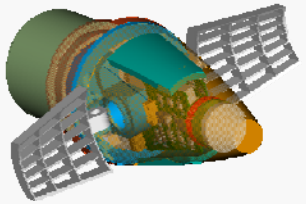
Presented By: Wayne Worrell
GIF Project Manager

Naval Surface Warfare Center, Dahlgren Division
Precision and Advanced Systems Branch, G33
540-653-6025, wayne.worrell@navy.mil

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BACKGROUND



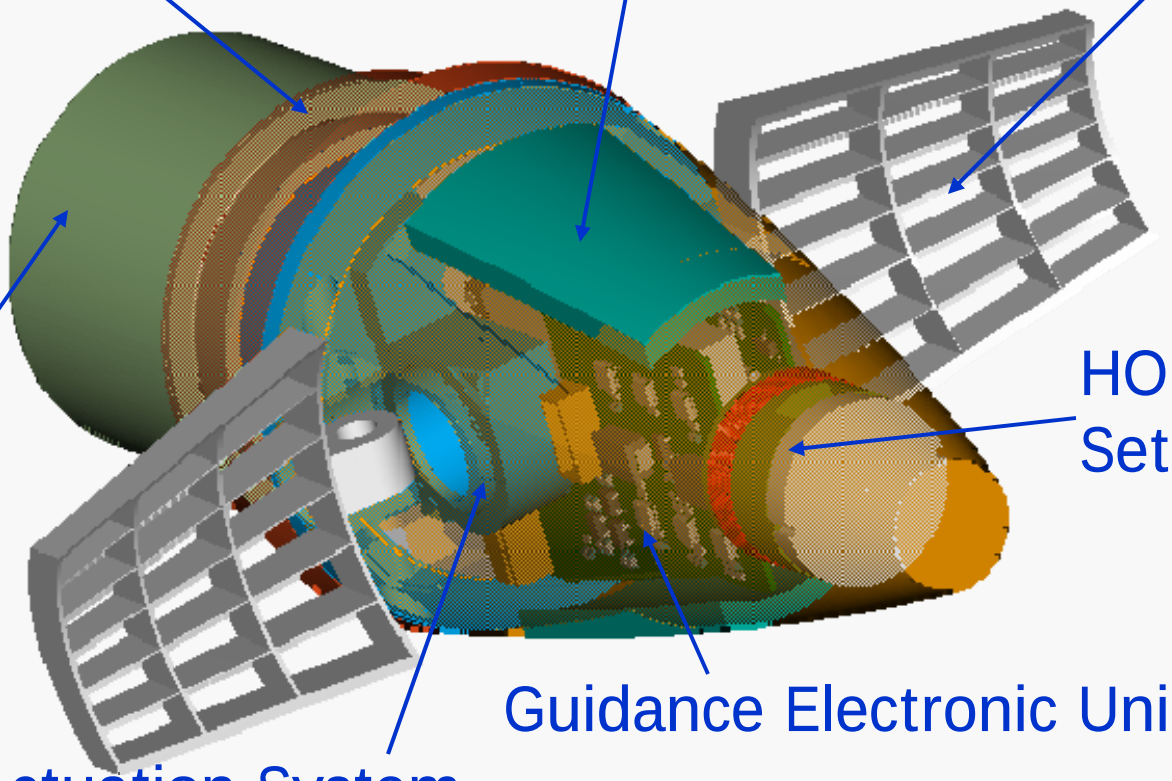
- The Guidance Integrated Fuze "GIF" program is in its last year of Demonstration Development.

- The Naval Surface Warfare Center was given two tasks:
  - Produce a self contained NATO standard fuze with integrated guidance to increase the accuracy of existing gun projectile inventories.
  - Produce a SAASM P(Y) GPS receiver with reduced cost/power requirements and sized to fit within a NATO standard fuze contour.

- This presentation will review fuze subsystems developed during the “GIF” program, final system test results, and the development of the 40mm SAASM GPS receiver and “VIPER” fuze.

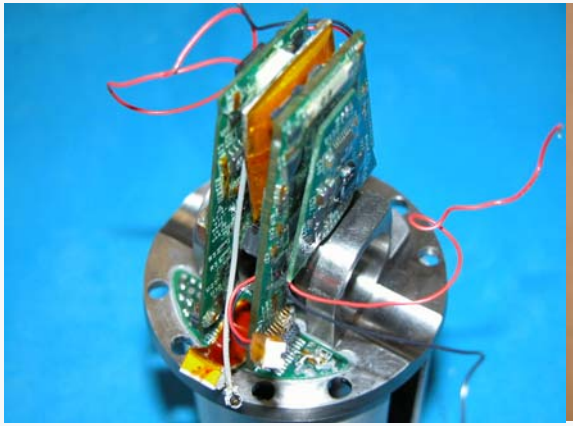
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GIF - Major Component Development

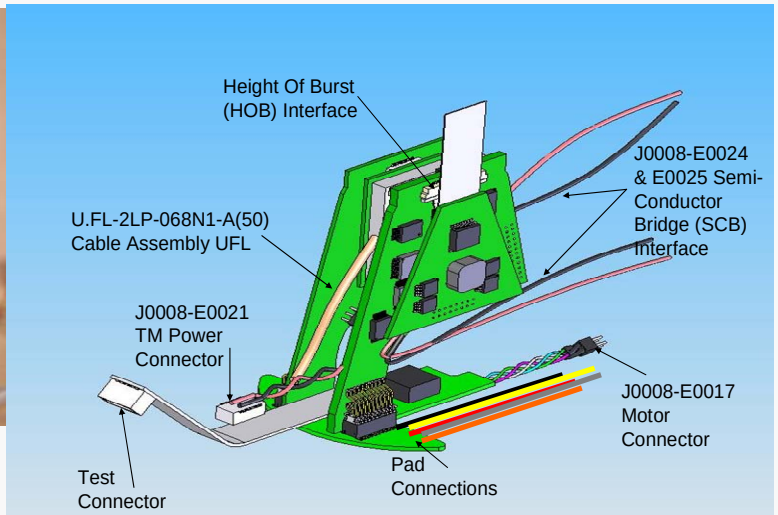


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Guidance Electronic Unit - GEU







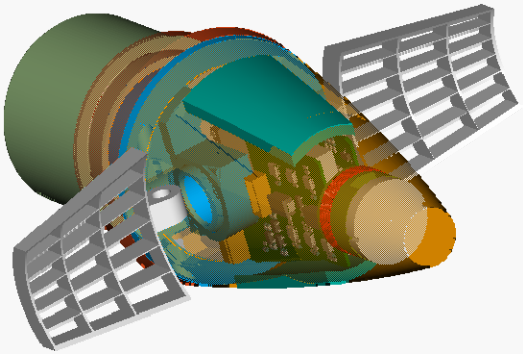
- Developed by Syntronics, Inc. for use in the Guidance Integrated Fuze “GIF”.

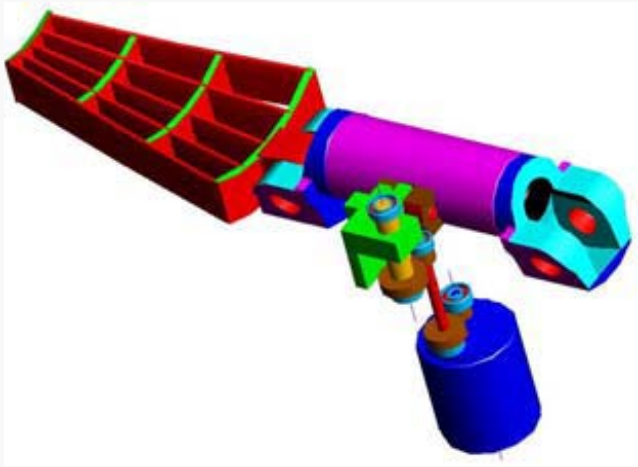
- The GEU successfully controlled: gun fire sensing, boot up, GPS receiver function, guidance computations, power regulation, roll brake control, canard deployment and control, HOB sensor control, fire pulse generation, and telemetry modulation data.

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Waffle CANARD



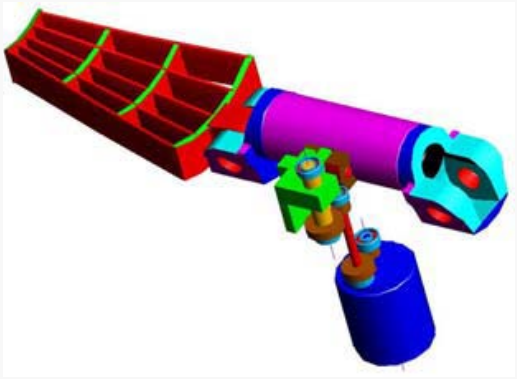




- Waffle canards were modeled, designed, analyzed, and wind tunnel tested by NSWCDD for our GIF fuze.
- Design gives more lift and less stalling than solid control surfaces of similar size.
- Design easily conforms to the fuze contour and required less hinge moments to deflect and hold canards.

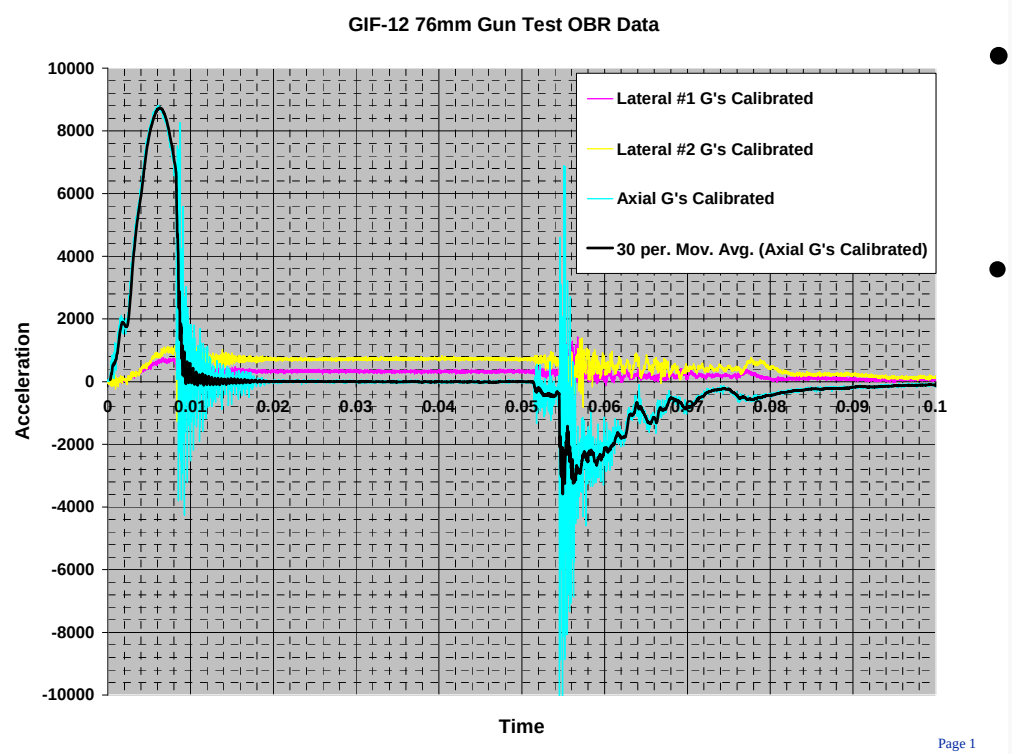
NAVSEA WARFARE CENTERS DAHLGREN

CANARD ACTUATION SYSTEM







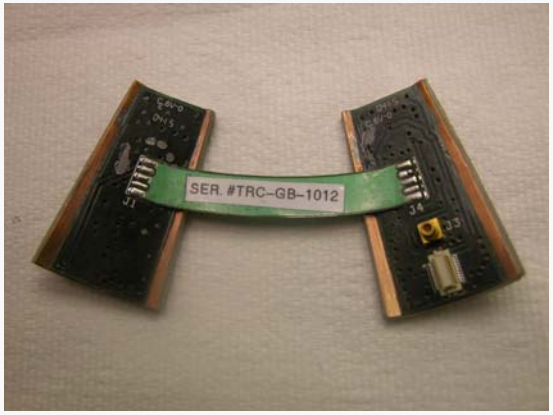


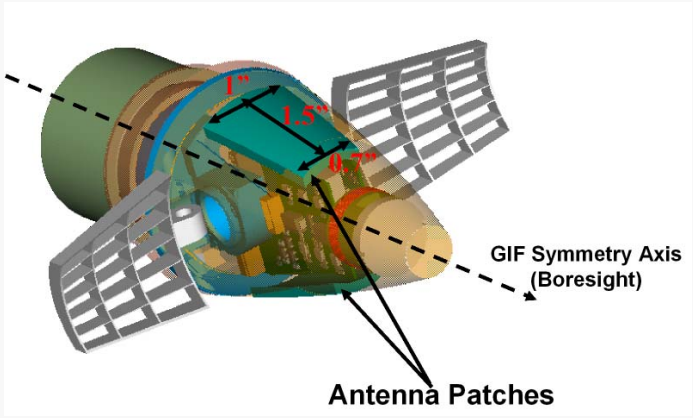
- A motor driven gear train was developed by CAES Corp.
- The CAS performed robustly. One system was tested five times to the gun G levels in the graph to the left and continued to perform without degradation.

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GPS ANTENNAS



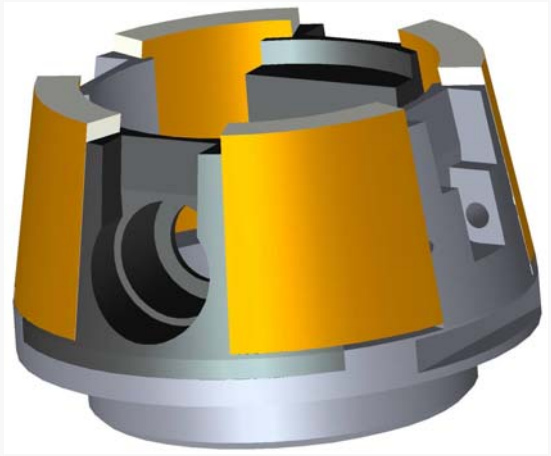


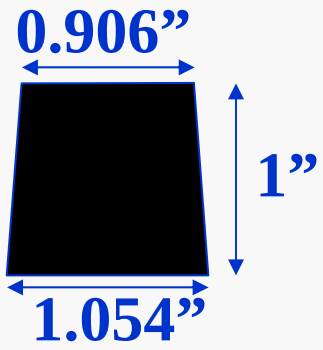


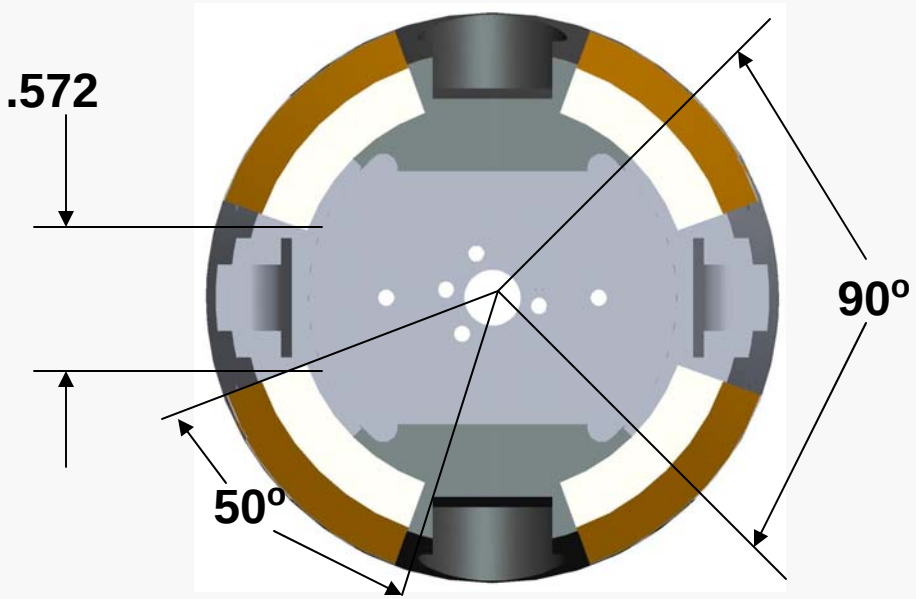
- Small aperture GPS antennas were developed to fit within NATO Standard Fuze dimensions by TOYON Research Corp.
- GIF uses two element active antennas.
- Four element linear and RHCP antennas were also developed.

NAVSEA WARFARE CENTERS DAHLGREN

TOYON Antenna Design
Passive Four Element







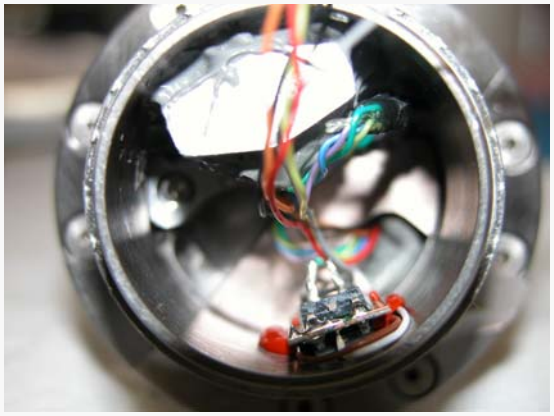
Tapered Profile Formed by:

- Bottom Radius – 1.208”
- Top Radius – 1.039”
- Thickness - .203”
- Axial Height – 1”
- Arc Width – 50º

Base of antenna sits .25” above the fuze shoulder.

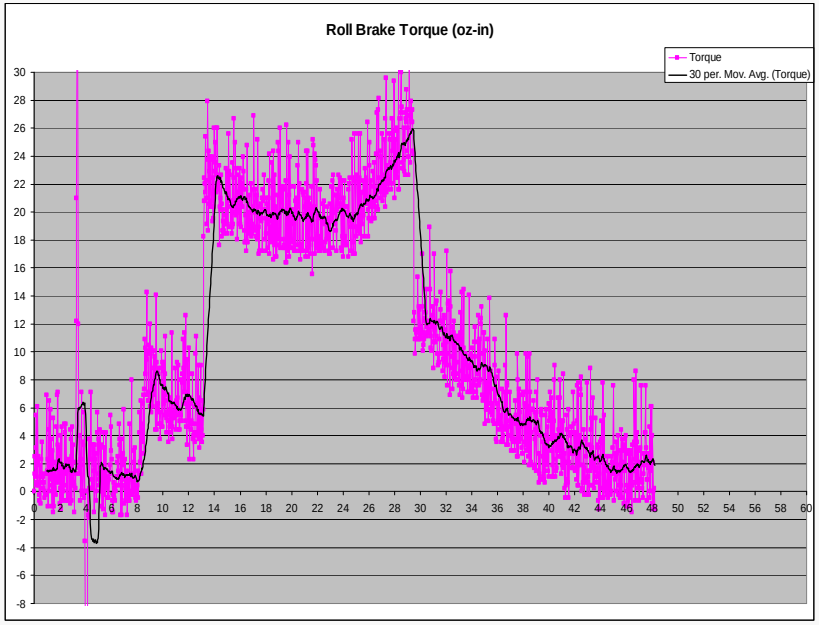
NAVSEA WARFARE CENTERS DAHLGREN

ROLL BRAKE





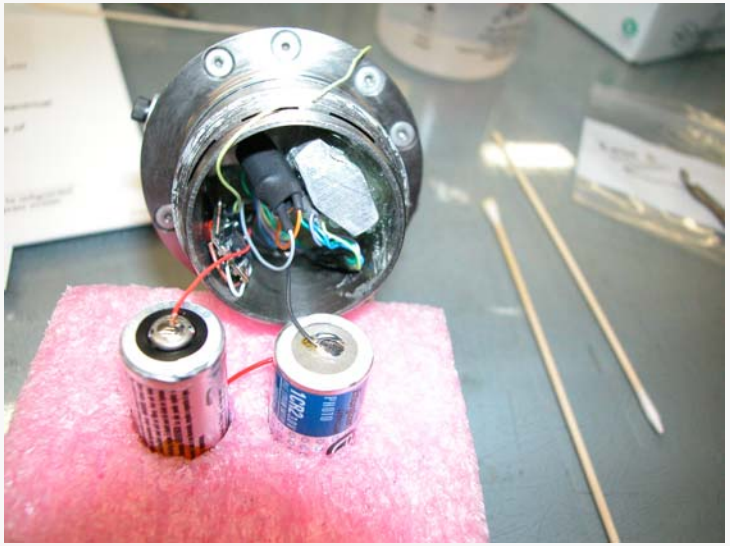




- Designed & produced by CAES Corp.
- The fuze is decoupled from the projectile body and a constant roll is induced in the opposite spin direction of the projectile.
- The roll brake is used to couple the fuze back to the projectile body by modulating the brake to hold the nose steady.

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CR2 BATTERY POWER

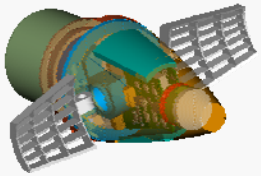




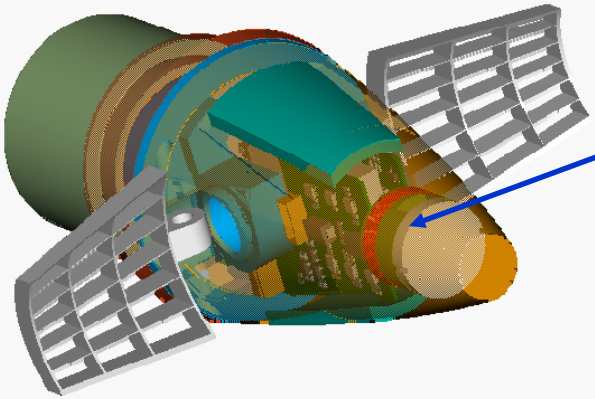
- Used commercial off the shelf batteries.
- G switch activated and used to power all fuze functions.
- The batteries survive gun shock.
- Artificial aging tests predicted a minimum shelf life of 7 years.

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Height of Burst & Inductive Set Repackaging

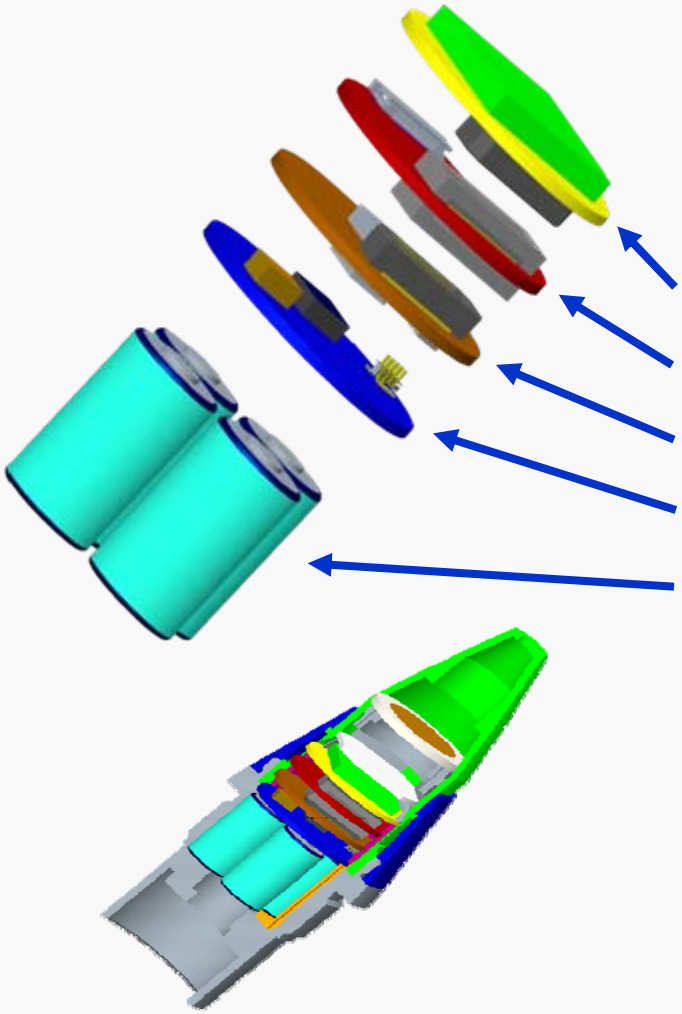


- Repackaged the MOFA signal processor into a single 1.075” diameter board solution.
- Coil form was shortened and coil modified to work with the EPIAFS setter.
- The standard MOFA antenna and MMIC was used.



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Electronic Test Fuze (ETF)



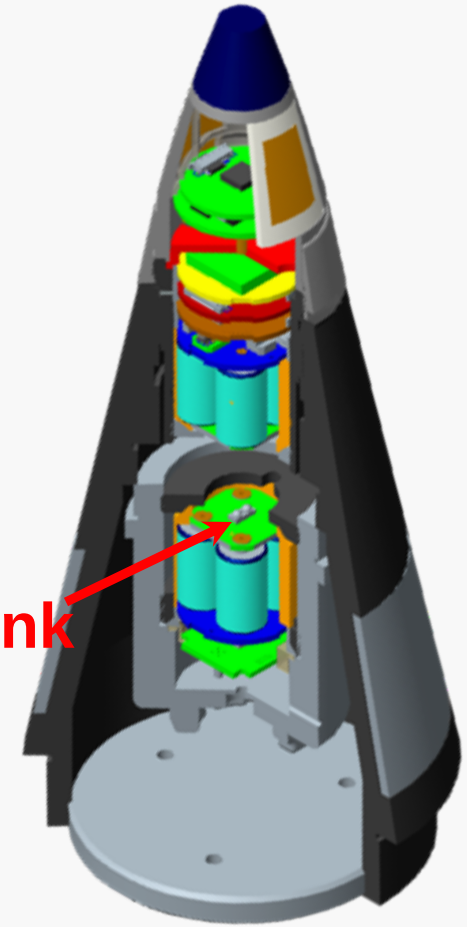
FPGA Board

FPGA I/O

Sensor Board

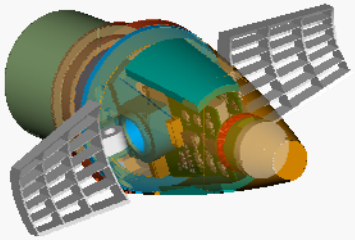
Power Board

Batteries

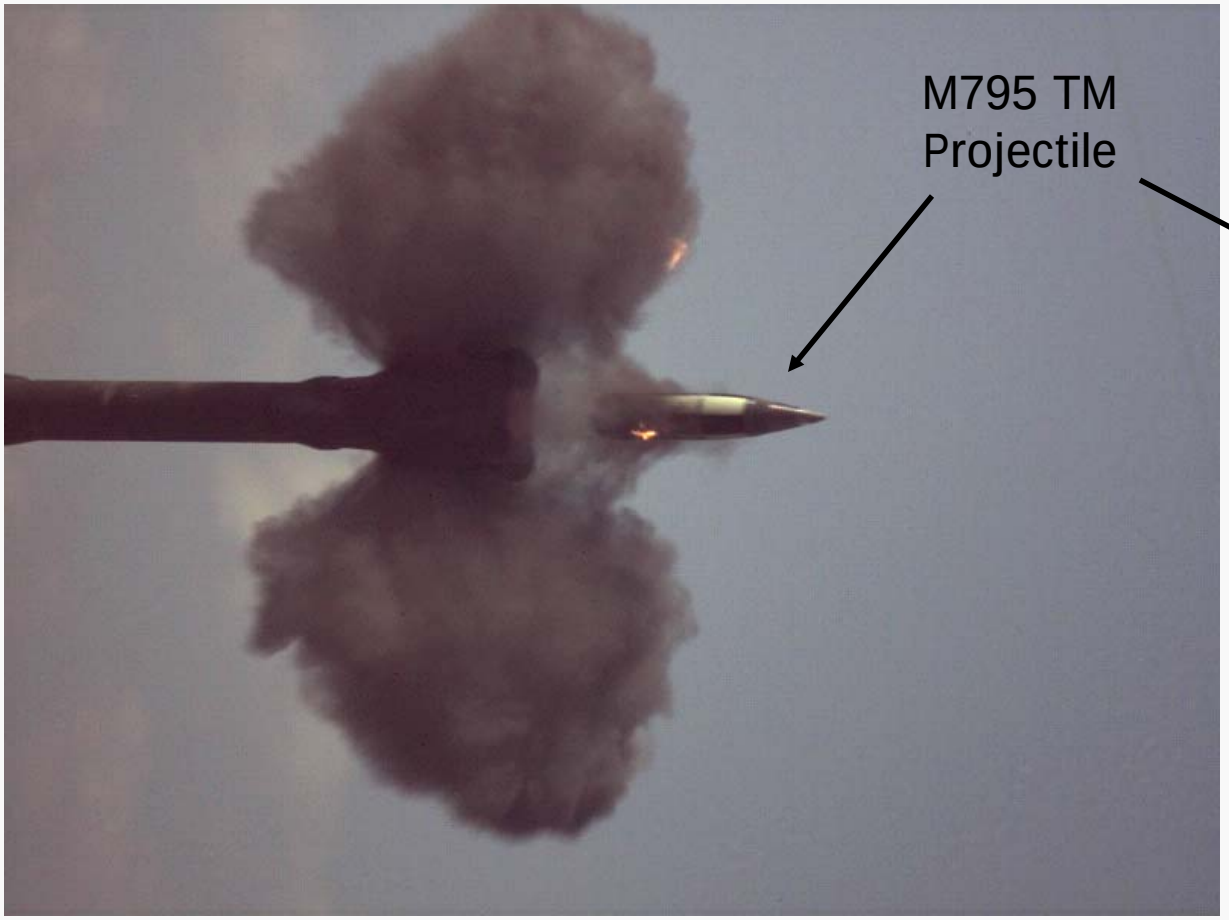


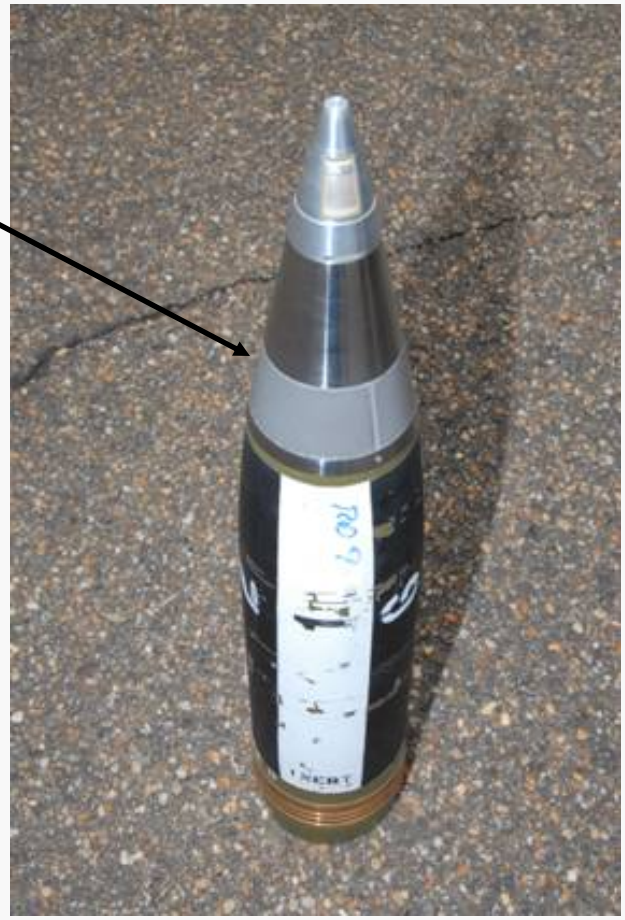
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Telemetry Projectiles



- M795
- M483
- M549 RAP

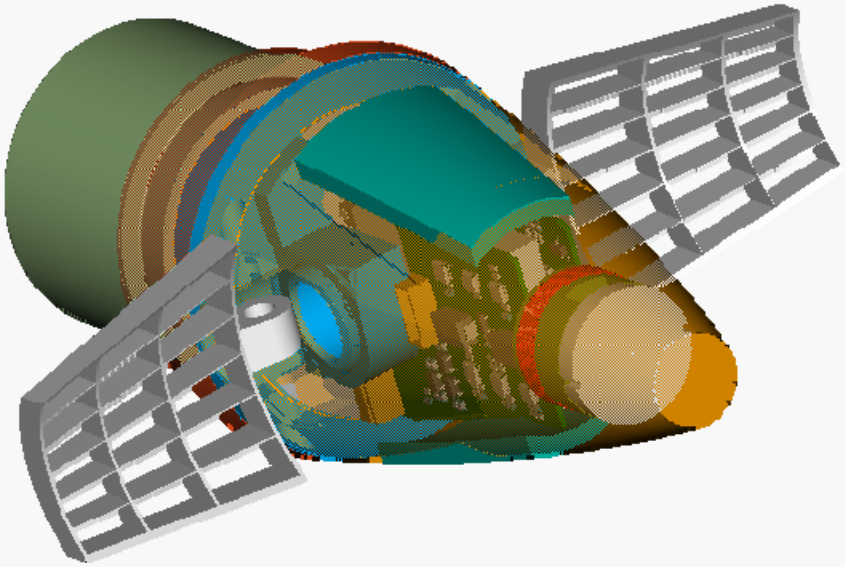




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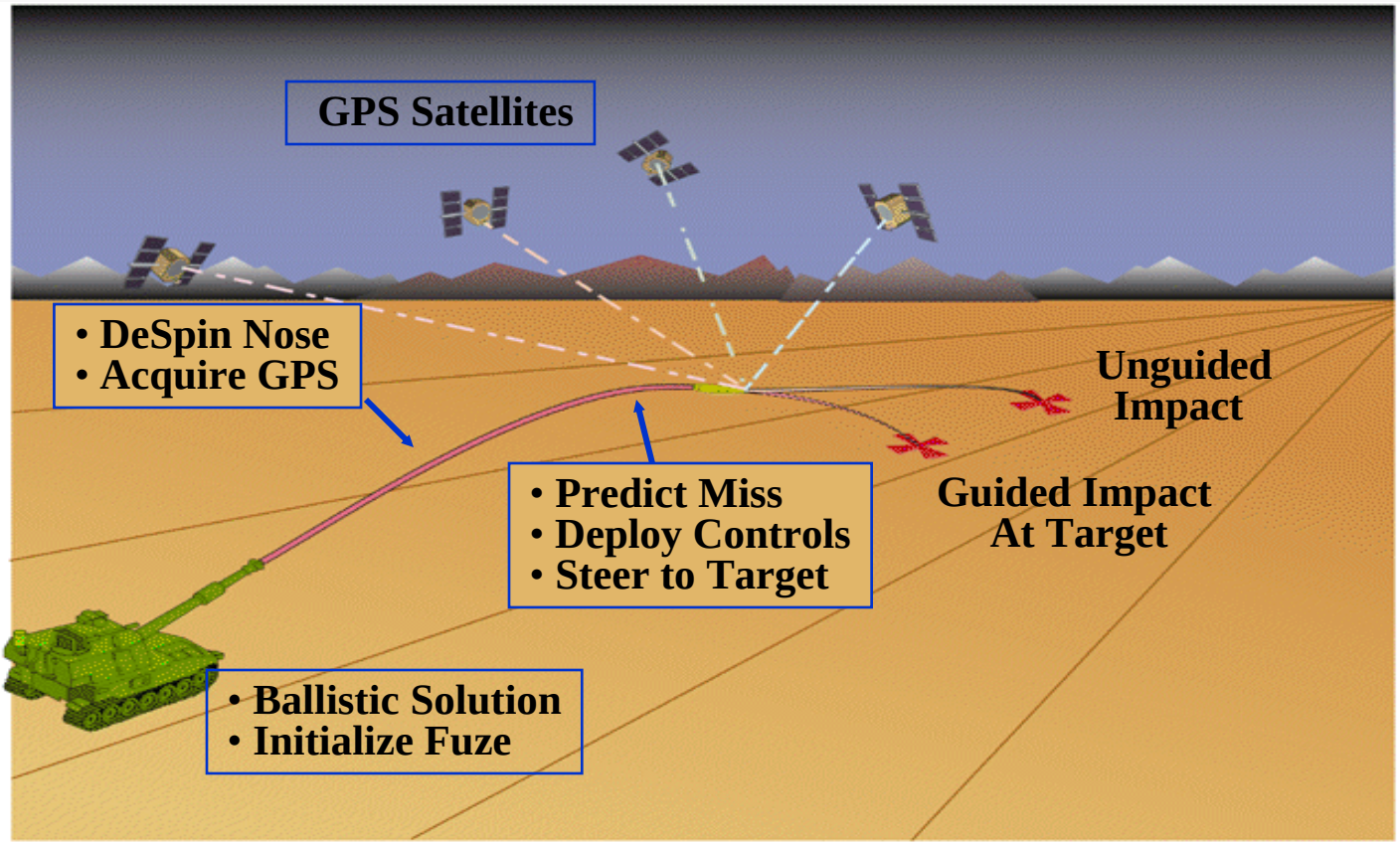
GIF

FLIGHT PERFORMANCE



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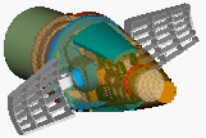
GIF FLIGHT SEQUENCE





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Final GIF 10 & 11 Test

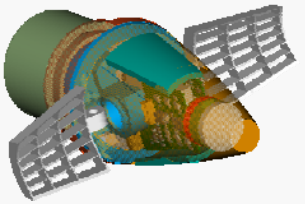


May 2008-Dahlgren Potomac River Test Range

- Two GIF fuzes were gun fired on 155mm, M483 telemetry projectiles.
- Objective: fuze survival, GPS navigation solution, and guidance performance of the control surfaces.
- Fired 14,000 yards, with a total flight time of 64 seconds. Telemetry data was received for full flight.
- GIF 10 and 11 survived shock, controlled nose position, acquired GPS solution, and expelled canard covers.
- GIF 11 appeared to not deploy canards and the projectile became unstable and fell short of the target.
- GIF 10 did deploy canards and achieved closed-loop navigation.

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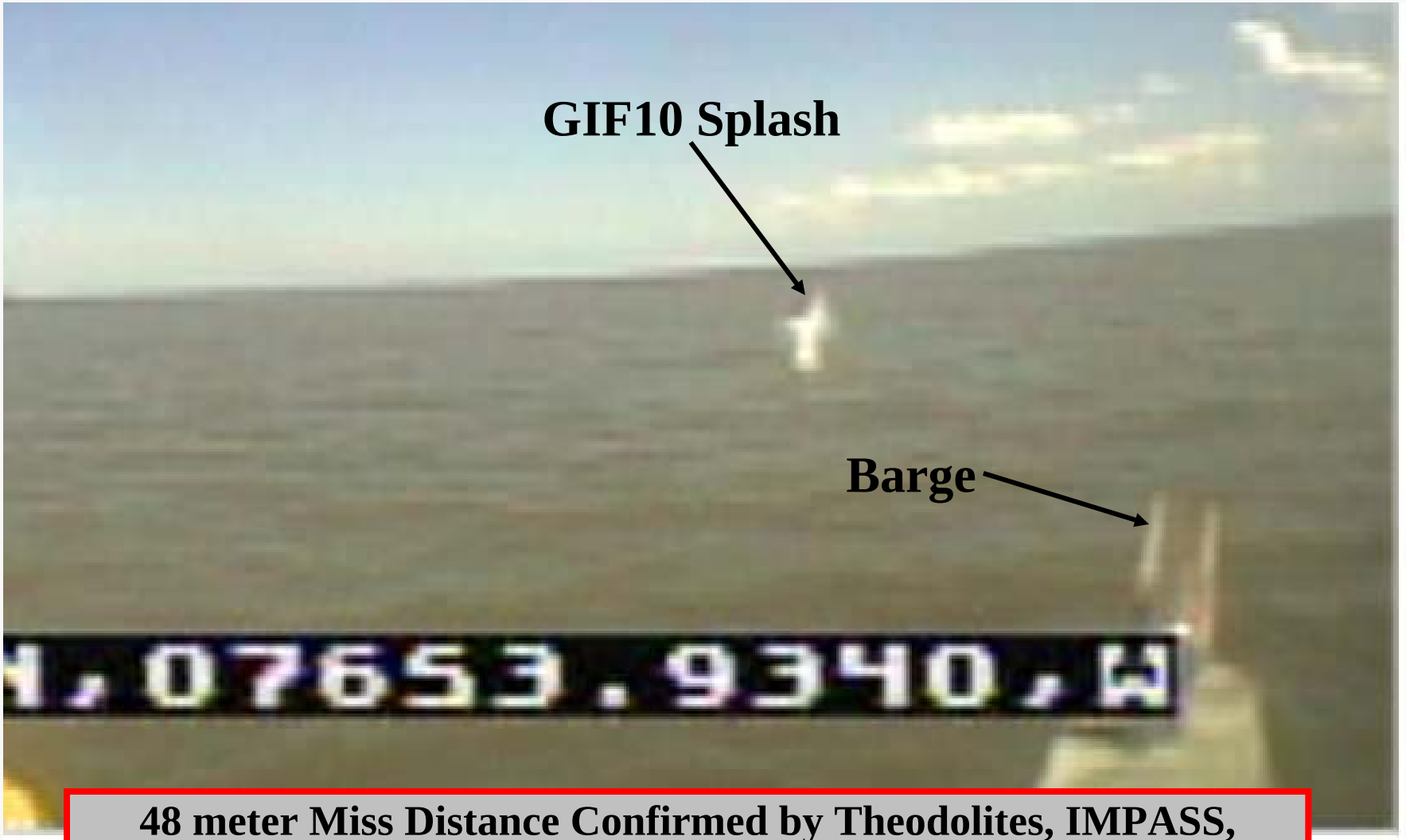
GIF10 Test Summary



- GIF10 achieved closed-loop Navigation of a NATO-Standard Fuze eliminating ~84m of miss and splashing ~48m from the programmed target coordinates.
- Launch Conditions should have resulted in an unguided miss in excess of 132m so the GIF fuze steered out about 64% of the error.
- Loss of nose roll control and (apparently) limited control surface deflections (<7 deg) adversely impacted the final accuracy.
- The guidance algorithm was properly estimating the final miss distance to within 2 m when nose control was lost.

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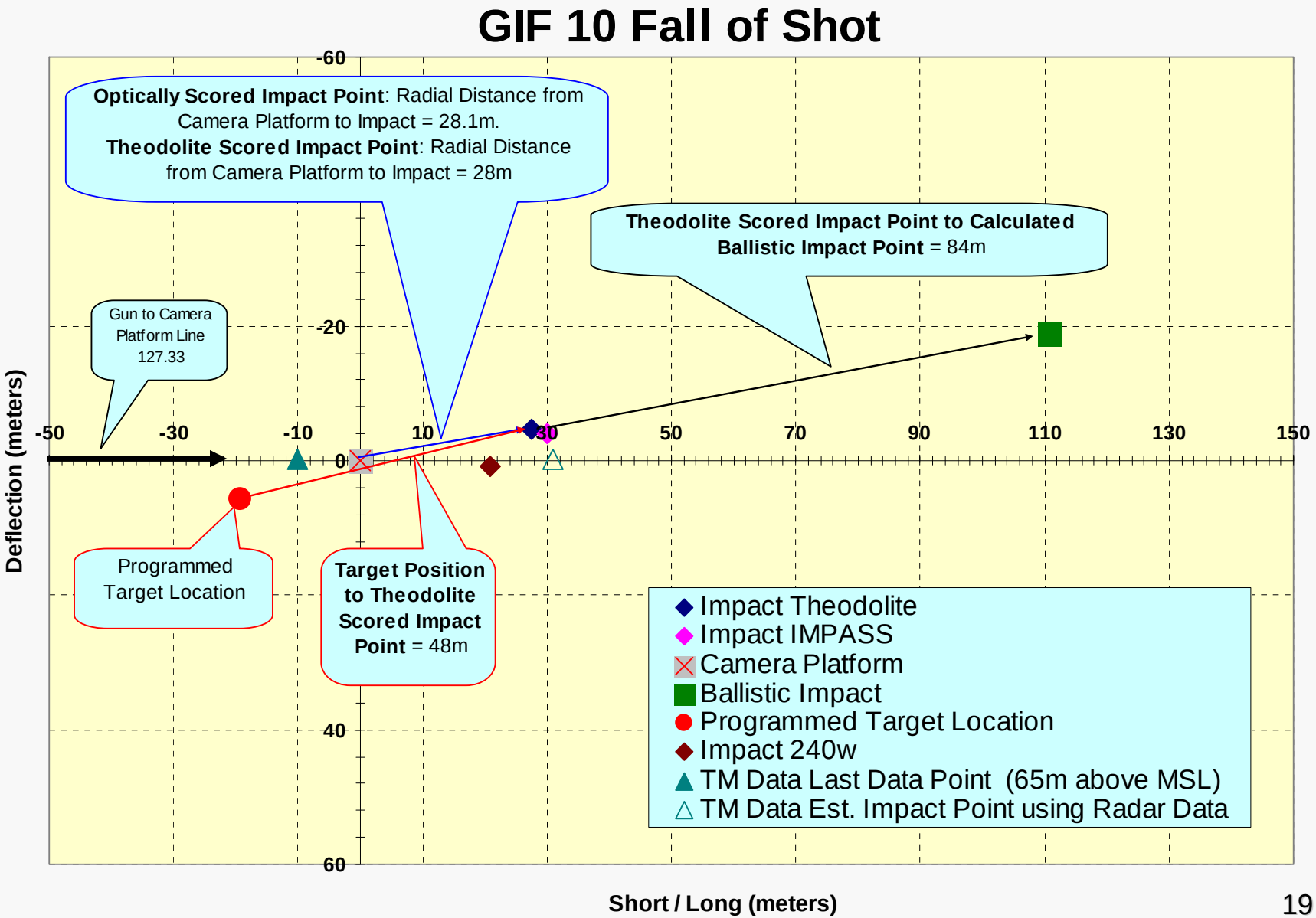
Photo of GIF 10 Splash
(48 M from target coordinate)



48 meter Miss Distance Confirmed by Theodolites, IMPASS, Optical Cameras, and GIF Navigation System.

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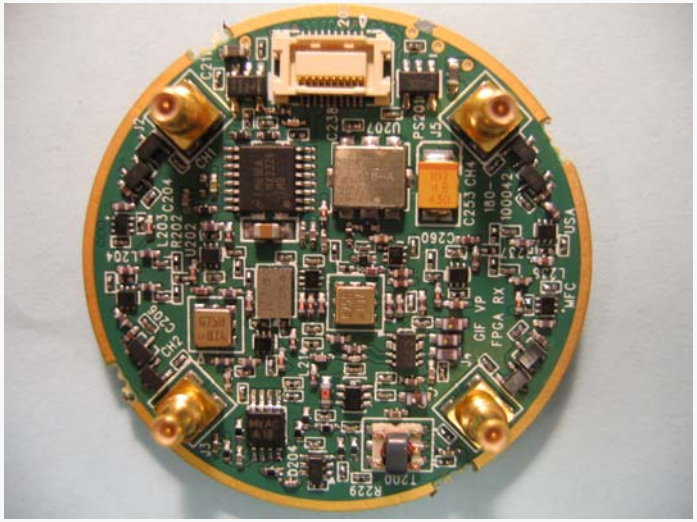
GIF 10 Scoring Performance



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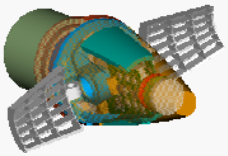
GPS SAASM Receiver Development

– Produce a SAASM P(Y) GPS receiver with reduced cost/ power requirements and sized to fit within a NATO standard fuze contour.



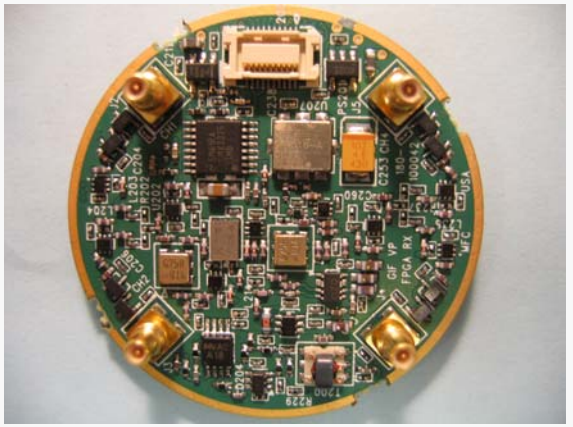
NAVSEA WARFARE CENTERS DAHLGREN

GPS SAASM Receiver



- No Existing Product Could Meet GIF Requirements
- Awarded Contract to Mayflower Communications Company, Inc. to Develop a SAASM GPS Receiver
  - Low Cost (< $500)
  - Low Power (< 1W)
  - Small Size (< 2 in^2)

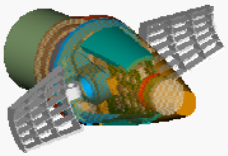




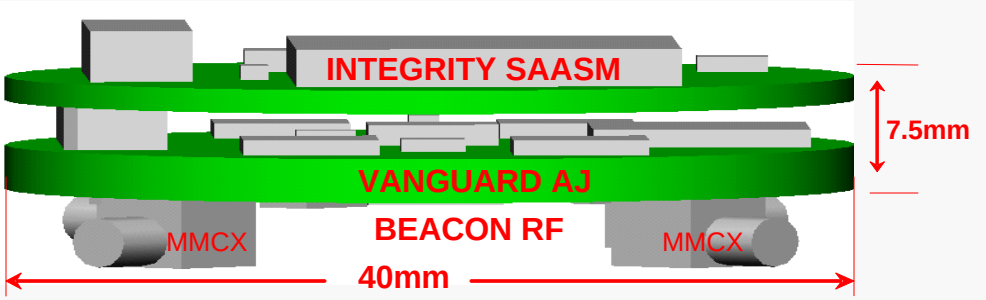
C/A Version
40mm dia.

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GPS SAASM Receiver
Cont’d



- Phased approach:
  - C/A Version w/ FPGA available now!
  - ASICs developed:
    - MAGIC C/A
    - VANGUARD AJ
    - BEACON RF
    - INTEGRITY SAASM
      - KDP-III-B
  - P(Y) SAASM Receiver Available Mar. 2010



P(Y) SAASM Version

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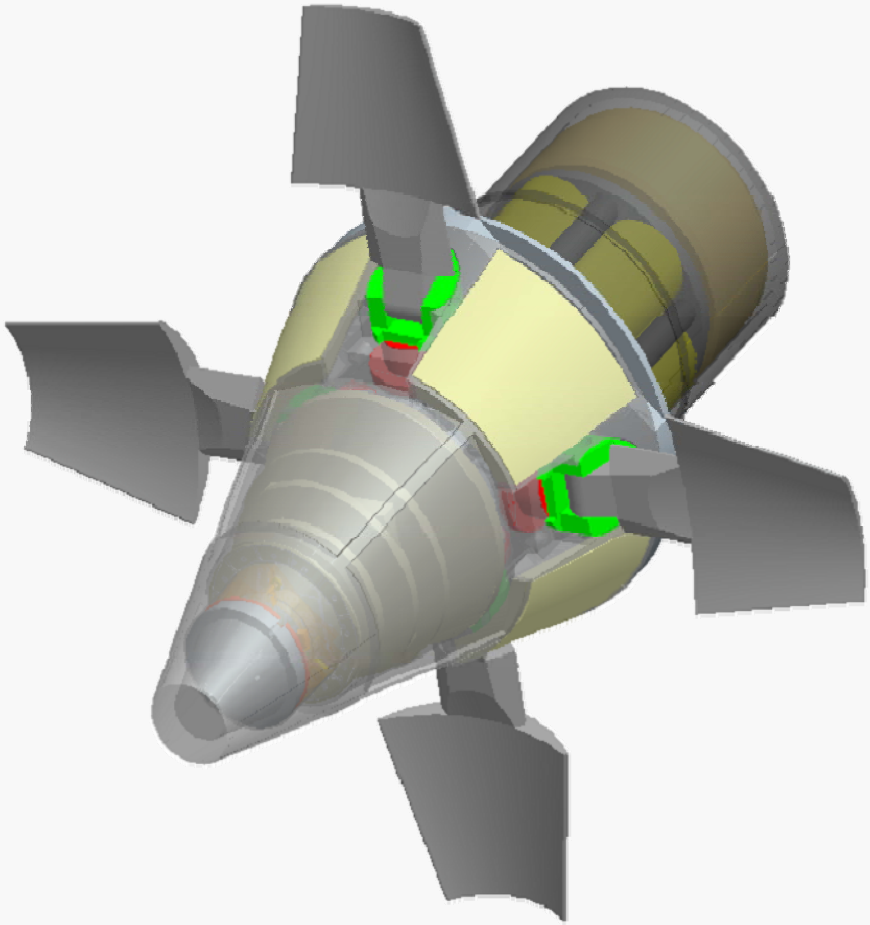
Up-Find & Anti-Jam Work

- Under our existing Navy contract, Mayflower Communications is tasked to:
  - Enhance the SAASM GPS receiver with an up determination capability using Satellite phasing alone (no sensors needed).
  - Complete the Anti-Jam module developed under a previous Navy contract.
  - The Army has funded these two tasks.

- Mayflower and NSWCDD are working toward:
  - Proof of Up-Finding in a jammed environment, up to three jammers, during 0 to 300Hz spin rates.
  - This testing will be done at Holloman AFB in mid May 09.

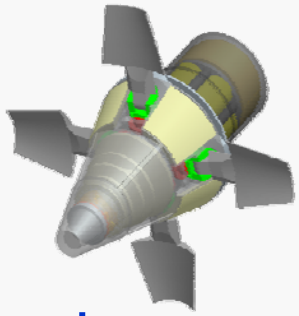
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VIPER FUZE DESIGN



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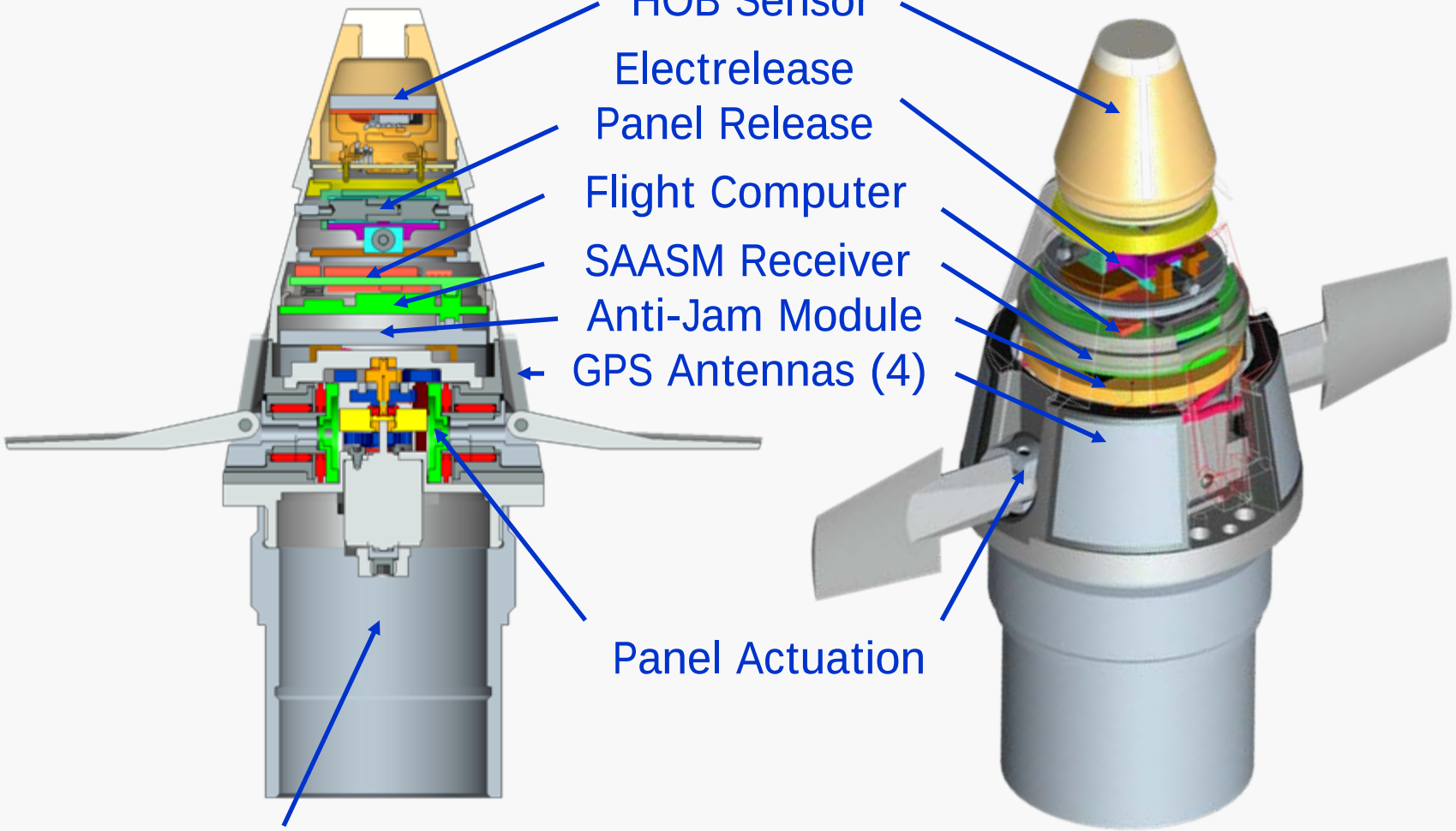
VIPER DESIGN, WHY?



- In FY 2006:
  - The Army’s 155mm, M549 RAP projectile became the primary proof of concept projectile type (was M795).
  - CEP defined at 30-50 Meters
  - Design need not conform to a NATO standard contour.
- The GIF fuze had marginal control authority on a M549 projectile body per wind tunnel data.
- The Navy decided to pursue an in house guided fuze design which performed independent of the projectile body.

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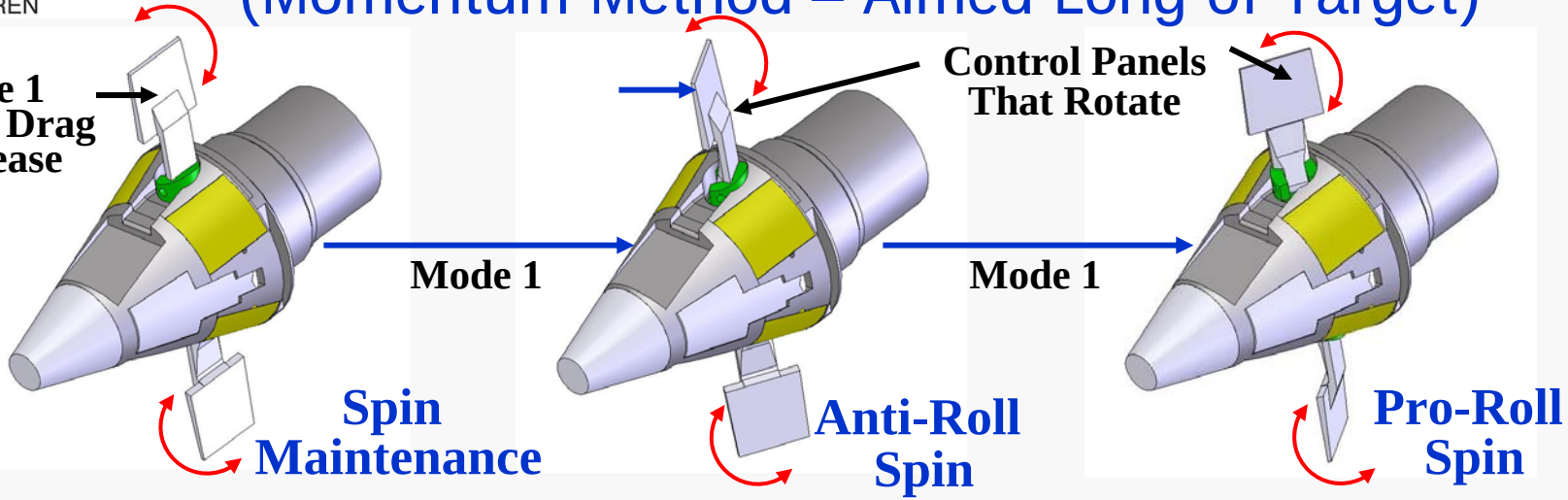
“VIPER” Sectioned View



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VIPER Control Modes

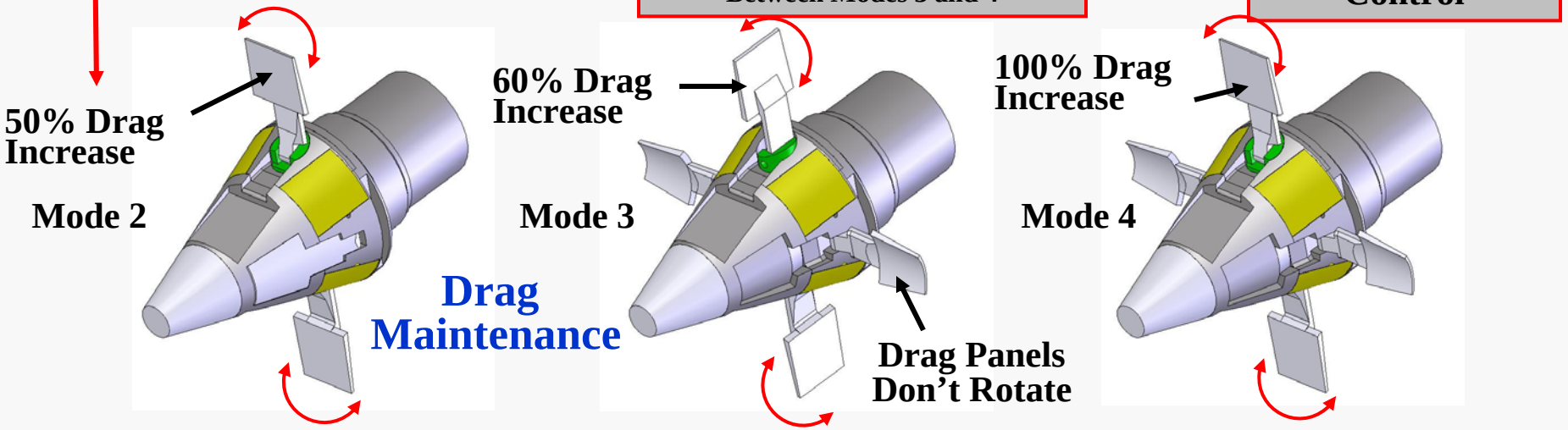
(Momentum Method – Aimed Long of Target)



Drag "Throttled" At 10% to 50% (Modes 1 to 2)

Drag "Throttled" at 60% to 100% Between Modes 3 and 4

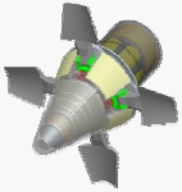
All Drag Modes Have Spin Control



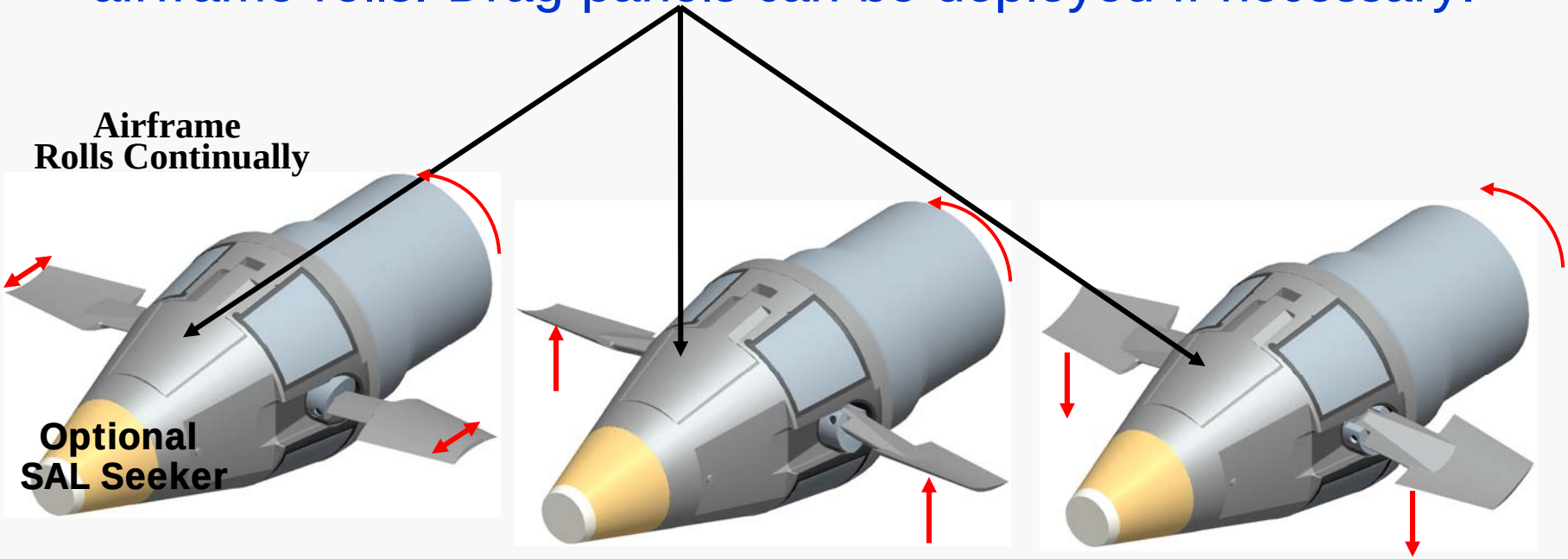
Drag Mode States Generally Increase as the Time to Impact Decreases

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VIPER Control Modes
(Lift Method)



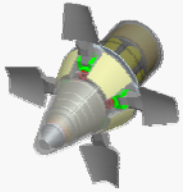
Control surfaces move together in a sinusoidal pattern as the airframe rolls. Drag panels can be deployed if necessary.

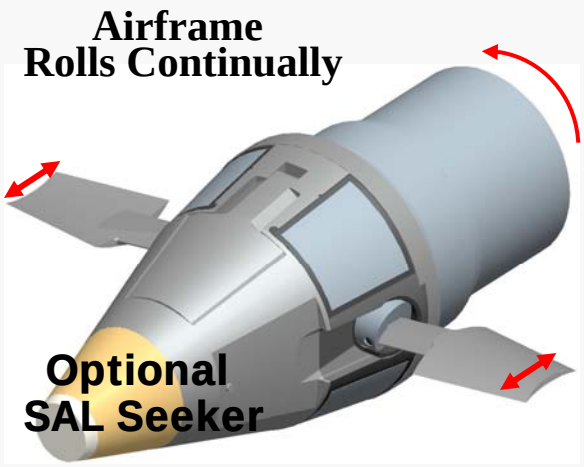


- All Fin-Stabilized munitions roll continuously due to fin cant. VIPER can shift to it’s “Lift Mode” Configuration.

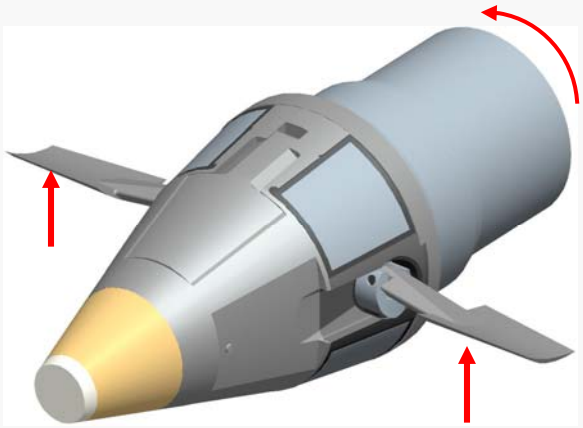
NAVSEA WARFARE CENTERS DAHLGREN

VIPER Control Modes
(Lift Method) Cont'd

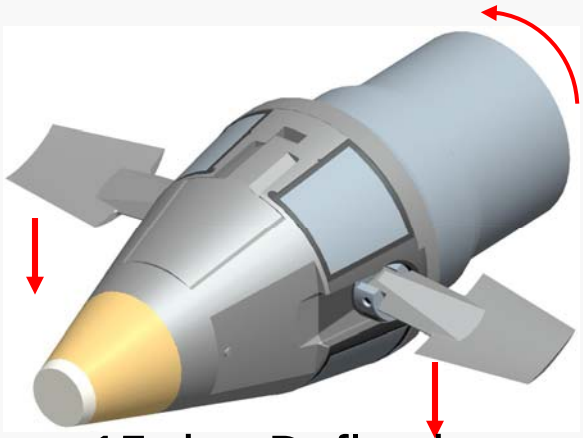




0 deg Deflection



+15 deg Deflection



-15 deg Deflection

- In this mode, the VIPER control system modulates its control surfaces in phase with the desired maneuver correcting both range and cross range errors.
- A CEP of less than 10m using GPS and approximately 1m with an Optional Semi-Active Laser (SAL) Seeker can be achieved.

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QUESTIONS

DoD Fuze Integrated Product Team

Chuck Kelly

OUSD(AT&L)

Land Warfare & Munitions

20 May 2009

OUSD(AT&L)/A&T/PSA/LW&M
Room 5C756
3090 Defense Pentagon
Washington, DC 20301-3090

(703) 695-1772
DSN 225-1772
charles.kelly@osd.mil

Agenda

- DoD Fuze IPT - Membership / Strategic Plan
- Vision / Fuze Roadmaps
  - High Reliability
  - Tailorable Effects
  - Hard Target
- DoD Fuze Science & Technology Program
  - History
  - FATGs
  - Process / DOTC
- TATB



Secretary of Defense
Hon. Robert Gates

Deputy Secretary of Defense
Hon. William Lynn



Under Secretary of Defense for Acquisition, Technology & Logistics
Hon. Ashton Carter



Principal Deputy : Vacant

DUSD(Acquisition & Technology)
Vacant

Secretary of the Army
Hon. Pete Geren

Secretary of the Navy
Actg. Hon. BJ Penn

Secretary of the Air Force
Hon. Michael Donley

Director, Portfolio Systems Acquisition
Mr. Dave Ahern



Land Warfare & Munitions
Mr. Tony Melita



DoD Fuze IPT Membership

- **OSD**
  - AT&L / Land Warfare & Munitions
  - AT&L / Defense Threat Reduction Agency
  - AT&L / Director of Defense Research & Engineering
  - AT&L / DCMA
  - Policy
- **Military Services**
  - Air Force
  - Army
  - Marines Corps
  - Navy
- **Department of Energy**
  - Lawrence Livermore National Laboratory
  - Los Alamos National Laboratory
  - Sandia National Laboratories

Strategic Plan

- Fuze Industrial Base Strategic Plan
  - Goal #1: Advance and maintain a healthy U.S. contractor base
  - Goal #2: Ensure that the Government develops and maintains the capability to execute its responsibility to assure the safety and suitability for service of fuze systems
- Fuze Technology Base Strategic Plan
  - Goal #1: Advance and maintain a healthy U.S. fuze technology base
  - Goal #2: Establish early and continued Government involvement in the development, application, and transition of fuze technology to munitions development

Fuze Roadmap

Background / Drivers

- Address priority capabilities identified in strategic guidance
  - Hard target / Agent defeat / Minimum collateral damage
- Address new DoD cluster munitions policy (<1% UXO) June 19, 2008
  - Precludes use of non-compliant cluster munitions; > 5 million in U.S. inventory
  - No waivers, no grandfather clause
- Increasing efficiency and effectiveness of the fuzing technology base & industrial base
  - Need to provide enabling fuze technologies to support future needs
  - Exploit enabling technologies to provide fuzing capabilities for miniaturization and high reliability

High Reliability Fuzing for (Cluster) Munitions Vision





99% + Reliability Fuzing

Short term - Self-Destruct Fuzing (SDF)

- •Develop a submunition fuze that approach requirement of 1% UXO
- •Retrofit SDF on existing DPICM hardware

5-8 Years – High Reliability CM Fuzing

Completely new submunition that:

- •Virtual elimination of UXO via fuze reliability using Tri-Modal Fuzing
- •Maintain effectiveness against traditional DPICM target sets
- •Relatively low cost to implement

Long Term – High Reliability

- • Universal fuze architecture that can achieve <1% UXO for all weapons

Tailorable Effects Weapon Vision



SDB-FLM



MK-82-FLM



Low Collateral
&
MK-82



Practice
Bombs

=

Dial A Yield Weapon

Reducing Collateral Damage and Optimized Lethality by Matching Output to Target

Hard Target and High Speed Weapon Fuzing Vision



Advanced Legacy Penetrators

BLU-109, BLU-122

Survive 10+ ksi, 2000 fps

10+ ksi concrete, survivability, Initial CCM



Boosted Penetrator

Survive 4000 fps

10+ ksi concrete;

UHPC, Enhanced CCM



CAV-like/ Hypersonic Weapon

Survive 4000+ fps

UHPC,

Geological structures (granite),

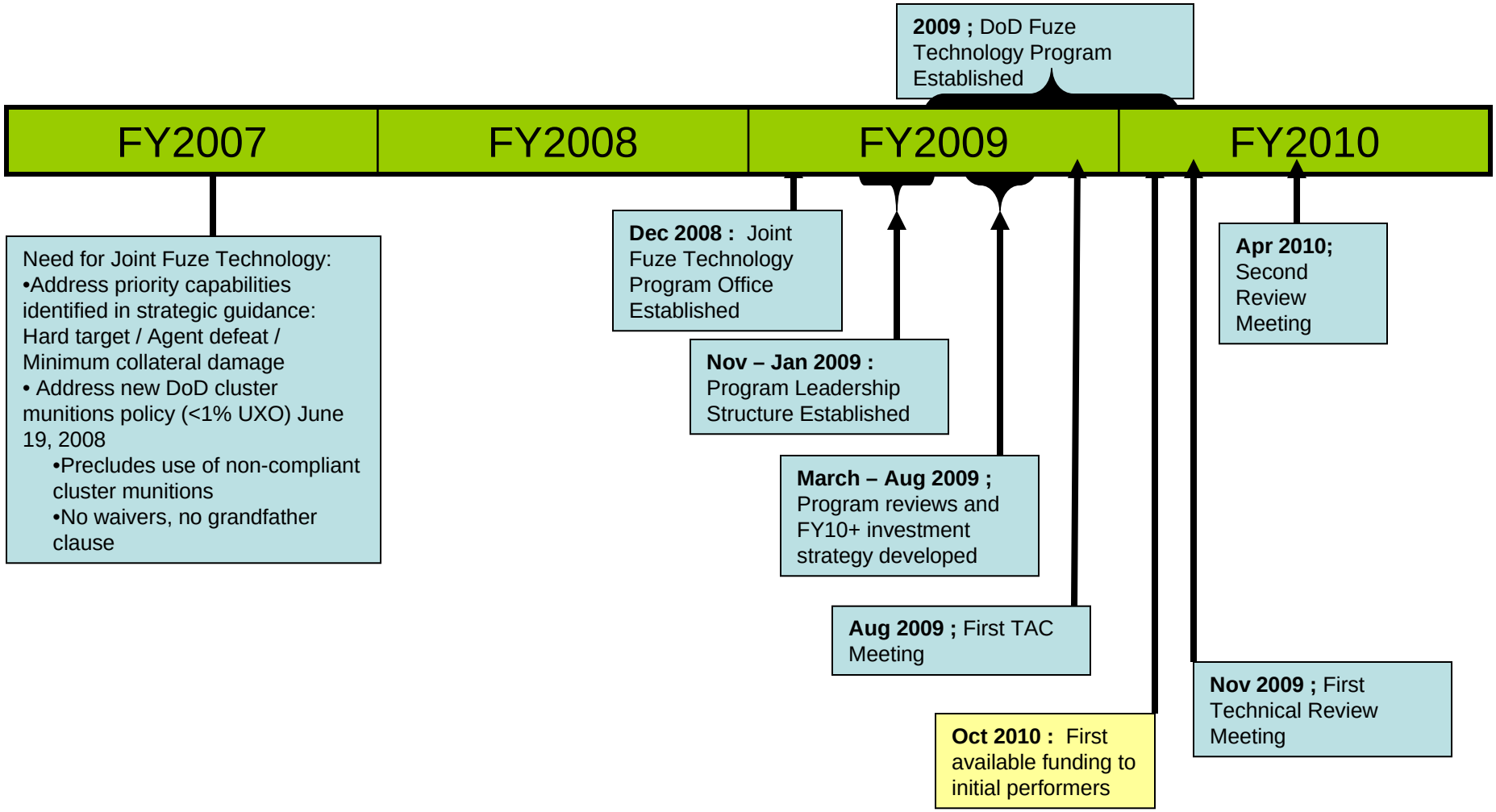
Advance CCM

DoD Fuze S&T Program

Overview

- Established program in the POM10 process
- High Reliability and Survivability were drivers
- Funding approved for FY10-15: $79.8M
  - 6.2 and 6.3 funding sources
- $10.6M in FY10

JFTP History

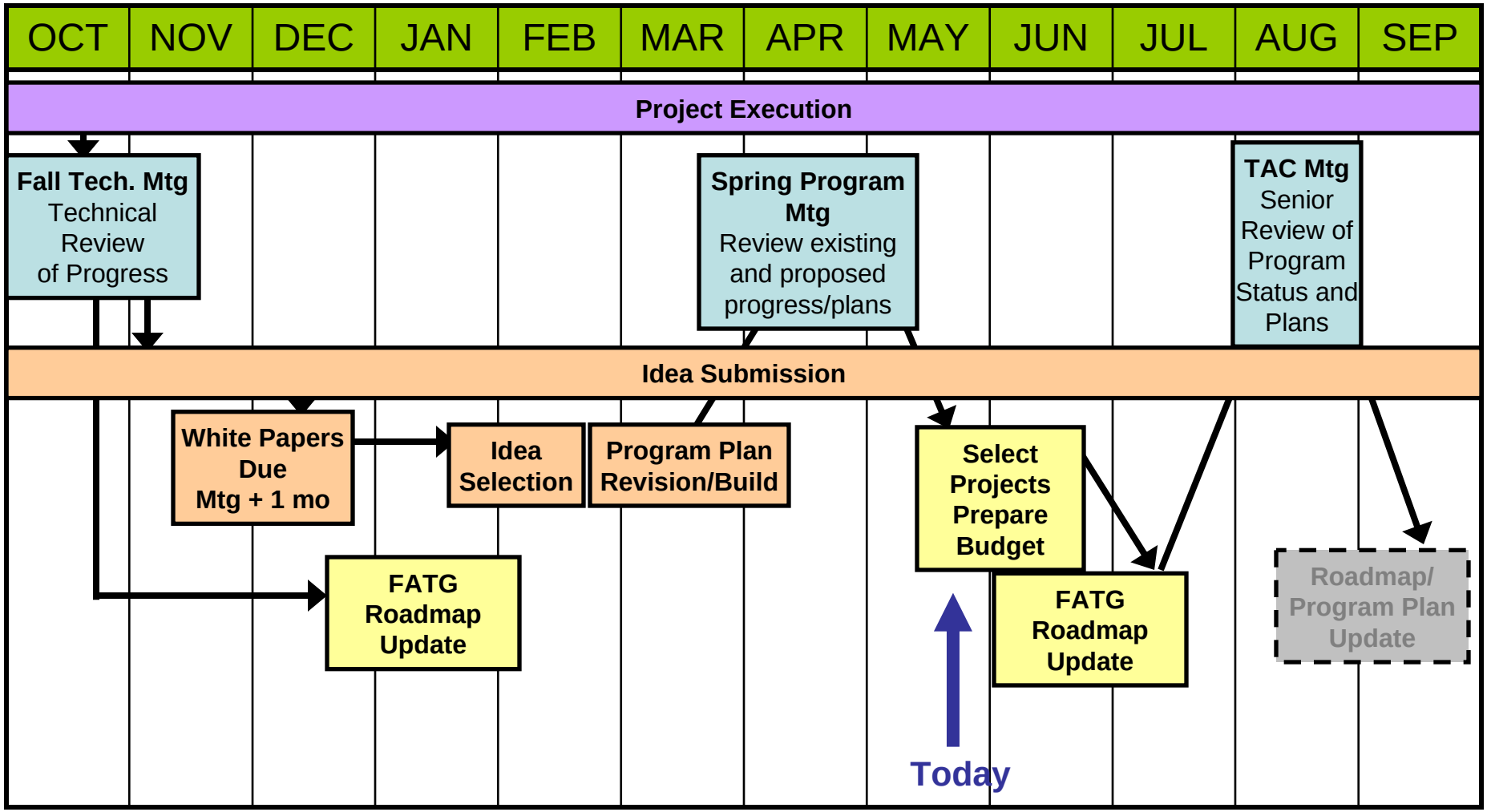


First annual process is FY10 start

FATG Leads

Lead	Co-Lead	Co-Lead	Co-Lead
FATG I – Hard Target Fuzing			
Howard White AFRL	John Kandell NAWCWD	Bill Konick ARDEC	Danny Hayles DTRA
FATG II – Tailorable Effect Fuzing			
Gene Henderson AMRDEC	David Olson NSWC IHDIV	Eric Welle AFRL	
FATG III – High Reliability Fuzing			
John Hendershot NSWC IHDIV	Tom Crowley ARDEC	Steve Smith AFRL	Danny Hayles DTRA
FATG IV – Enabling Fuze Technologies			
Chris Janow ARDEC	Matthew Bridge AFRL	Bruce Hornberger NAWCWD	

Annual Cycle



FY11 JFTP Submission

➢**ALL DATES TENTATIVE**

- Mid-November ‘09 Call for FY11 White Papers (DOTC)
- Mid-December ‘09 – Suspense for White Papers
- Early February ‘10 – Select New Ideas for Project Plan development
- Mid-March ‘10 – Project Plans due
- Early April ’10 – New Idea Project Plans briefed in closed session
- Mid-May ’10 - Final Project Plans due
- Late June ’10 - Budget Meeting – Projects selected for FY11 funding recommendation
- Early Aug ’10 - JIMTP TAC – Approval of FY11 budget

DoD Ordnance Technology Consortium (DOTC)

Government Laboratories

- OUSD (AT&L) LW&M
- Department of The Army
- Department of the Navy
- Department of the Air Force
- Department of Energy
- Special Operations Command
- Other Agencies and Departments

Rapid & Agile Acquisitions

Section 845
Other Transaction

National Warheads & Energetics Consortium

- Defense Contractors
- Traditional & Non-Traditional
- Academic Institutions
- Not-for-Profits Organizations

DoD and NWEC… Partnering to Leverage Capabilities and Investment

DOTC Benefits

- The DOTC OTA (FY09-FY16, $700M) is established and available to obligate funding
- Better collaboration among Government labs
  - Engagement of more DoD/DOE labs
  - Leveraging established DoD IPT processes
- DOTC supports partnerships, use of non-traditional contractors and education outreach
- DOTC provides a focal point to rapidly transfer technology to the Warfighter
- Visit web site at www.nwec-dotc.org for additional information

18

Road Ahead

- The DoD Fuze S&T program is late to need – WILL CONTINUE TO JUSTIFY NEED
- Program is addressing critical warfighter capabilities
  - Reliability
  - Survivability
- Our Investments are in 6.2 Applied Research and 6.3 Advanced Technology Development Fuzing
- Want to leverage DOTC to encourage NWEC submission of New Ideas in FY10 and beyond
- Need to ensure collaboration between Government and Industry

TATB
UPDATE

Background

- Triaminotrinitrobenzene (TATB) is one of the least sensitive explosive materials known
  - TATB is a critical ingredient in the booster explosives PBXN-7 and PBXW-14 for DoD applications
  - TATB is used in PBX 9502 and LX-17 for DOE applications
- 1993 CONUS TATB production ceased
- 1999 DoD begins OCONUS TATB procurement
- 2001 MANTECH efforts initiated
- 2005 last qualified OCONUS source ceased production and closed in 2006

Background

- 2006 DoD qualified BAE/Holston as a supplier for PBXN-7 using DOE/Pantex TATB (surplus)
- 2006 MANTECH unsuccessful in developing a production source for TATB within Spec.
- 2007 TATB DoD/DOE Working Group formed
- 2008 TATB NNSA/DOE Study Group formed

Current Systems Using TATB

- TATB is used in Two Booster Explosive Formulations
  - PBXN-7 (60% TATB, 35% RDX, 5% Viton A)
    1. FMU-139 fuze for BLU-110/111/113/117/126 and MK82/83/84 – 0.31 lb.
    2. FMU-152 fuze for BLU-110/111/113/117/126 and MK82/83/84 – 0.34 lb.
    3. FMU-143 fuze for BLU-116 and BLU-109 – 0.31 lb.
    4. BBU-47/B fuze booster for Tactical Tomahawk – 0.27 lb.
    5. BBU-60/B fuze booster for SLAM ER – 0.44 lb.
    6. MK436 fuze for MK146 (M229) warhead for 2.75” Rocket – ~0.02 lb.
    7. JSOW fuze – 0.34 lb.
    8. Mk 75 Safe and Arming Device booster for Quickstrike Mine– 0.64 lb
  - PBXW-14 (50% HMX, 45% TATB, 5% Viton A)
    9. M734A1 fuze for the Army and USMC M934 120-mm mortar – 0.02 lb.
- TATB is used in PBX 9502 and LX-17 applications for DOE

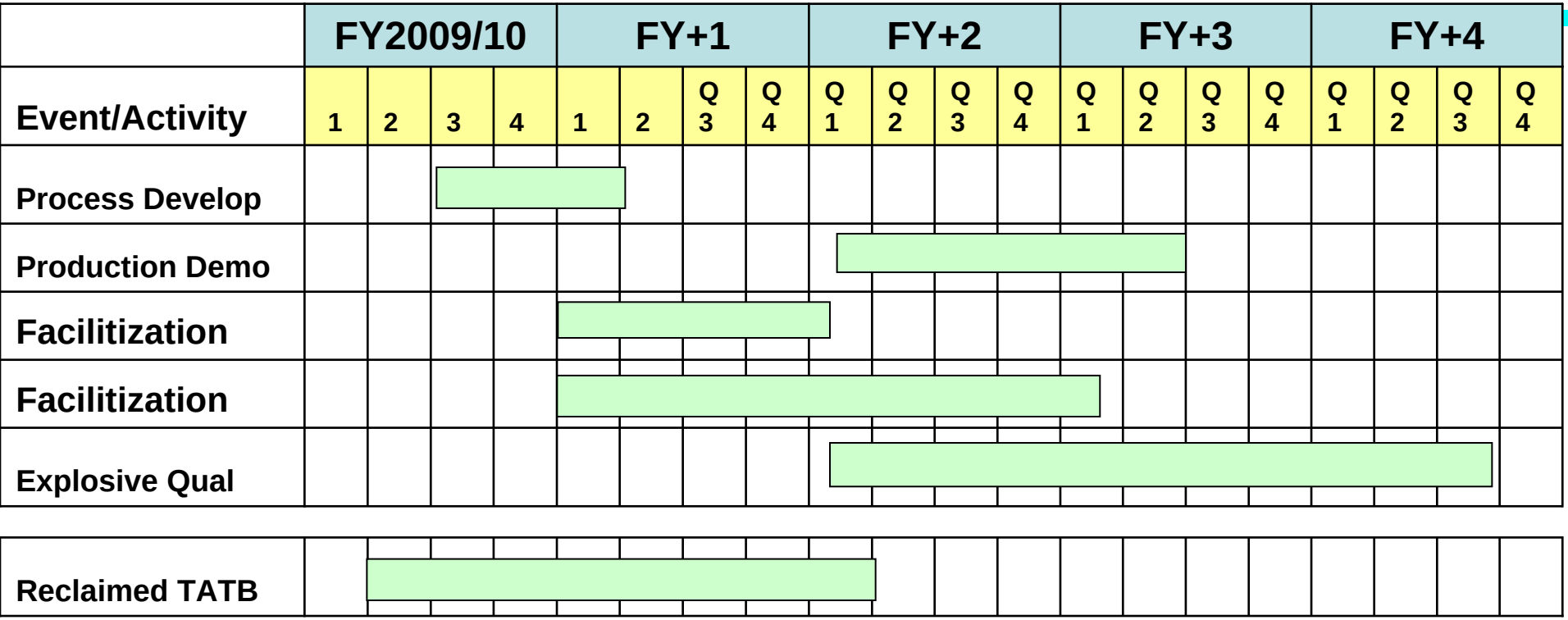
Issues

- **NO QUALIFIED INDUSTRIAL BASE CAPABILITY TO PRODUCE TATB (CONUS OR OCONUS)**

- **NO CONUS TCB Manufacture (RFI issued)**
  - **Environmental production challenges**

- **Time to establish path to a CONUS suppliers**

Timeline



Assumptions:

- TATB will be a "drop-in" replacement for existing TATB
- No system (fuze) level qualification required
- Contract award to two vendors for qualified TATB
- USG has oversight of projects
- US Army manages facilities contract
- OSD program oversite with DoD Fuze IPT TATB DoD/DOE Working Group
- BAE Holston manufactures PBXN-7

Way Ahead

- **Reestablish Benziger TATB Route**
- **Leverage DOE TATB Strategic Stockpile**
- **Funding for reclaimed TATB**

Bottomline

- **DoD will be dependent on DoE stockpile for at least the next two to three years**
- **Earliest relief may come from reclamation effort**
- **TATB will ONLY be available for DoD components and FMS**

Questions??

679 Armament Systems Squadron

53rd Annual Fuzes Conference

20 May 2009



U.S. AIR FORCE

679 ARMAMENT SYSTEMS SQUADRON

Distribution Statement A. Approved for public release; distribution unlimited.

Briefer:
Marcelious Willis, Jr.
679 ARSS
DSN 875-1282

Outline

- JPF System Description
- JPF Program Schedule
- Design Enhancement Qualification Status
- Sled Test Video– 15 Oct 08
- Aircraft Integration Update
- Initiatives
- Operational Reliability Summary
- Summary

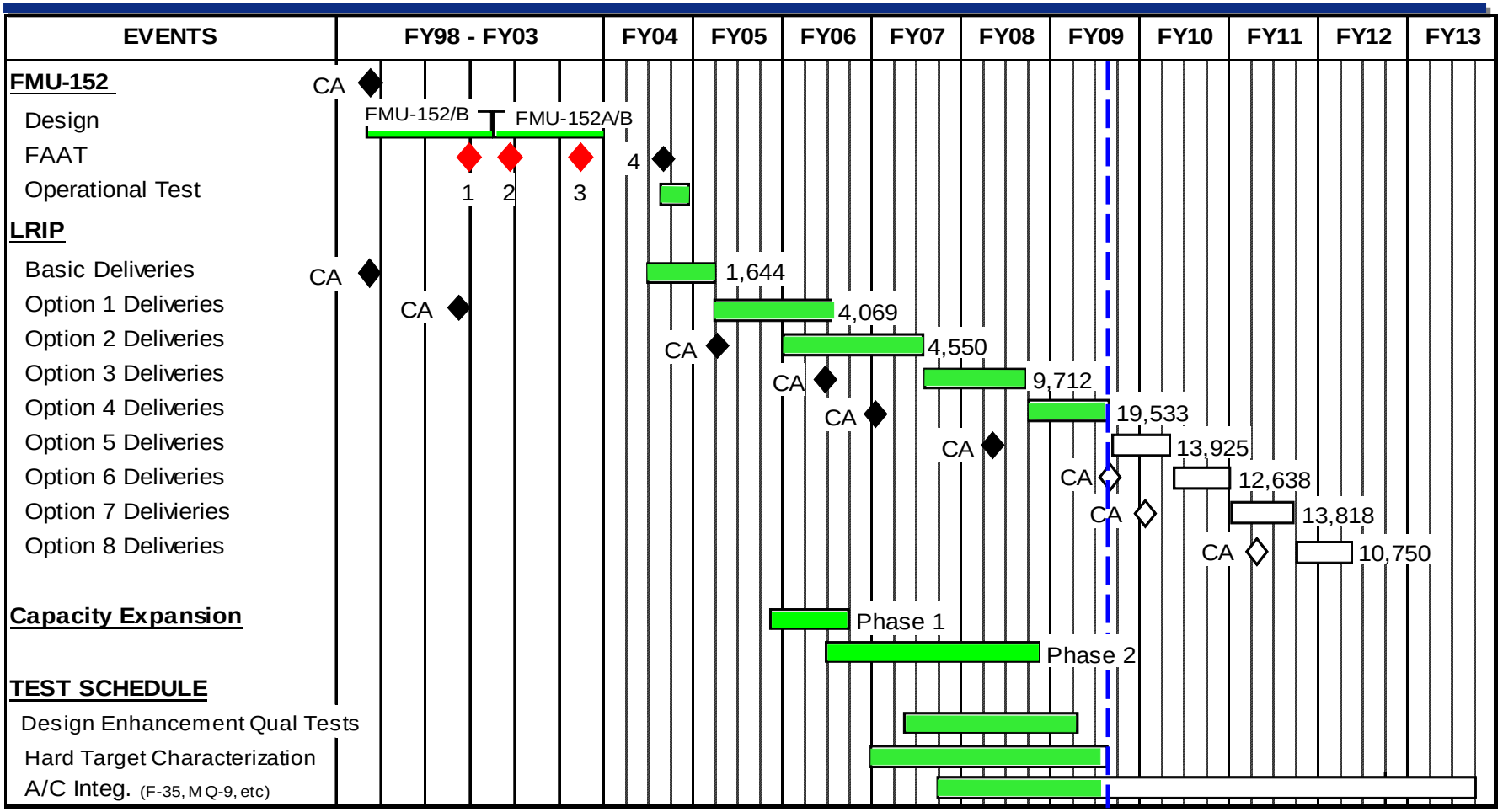
JPF System Description

- System - FMU-152A/B, FZU-55A/B, Power Cable, Closure Ring
- Requirements Based from JDAM JORD (CAF 401-91-III-A, 10 Mar 01)
- Cockpit Selectable Arm/Delay Times In-flight Retargeting (Through JDAM)
- Interchangeable with Current FMU-124, FMU-139, and Some FMU-143 Applications
- Single Tail Fuze Compatible with MK80 Series, BLU-109, BLU-110, BLU-113, BLU-121, BLU-122 and BLU-126 Warheads
- Weapons: All JDAM Variants, AGM-130 and GBU-10/12/15/16/24/27/28
- AF & Allied Nations (AF Lead)
- Built by Kaman Precision Products, Incorporated (Orlando, FL / Middletown, CT)





JPF Program Schedule



As of: 30 Apr 09

Design Enhancement Qualification Status

- Enhanced Design JPF
  - Changes Invisible to Operator
  - No Change to Way Fuze Operates
  - No Change to Nomenclature
  - No Change to Technical Orders
- Purpose of Enhancements
  - Producibility : Reduce Parts/touch Labor – Increase Production Yield
  - Testing: More Extensive Factory Test – Fewer Quality Escapes
  - Reliability: Deliver quality fuze
- Qualification of Enhancements & 2nd Production Facility
  - Completed Last Two Sled Test 24 Sep & 15 Oct
  - Two Flight Test Sorties – Dec 08 & Jan 09
  - Begin Enhanced Design Production at 2nd Facility – May 09

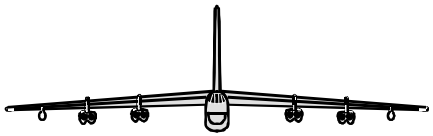
Continuous Improvement

Sled Test-15 Oct 08



Aircraft Integration Update

ON-GOING



B-52



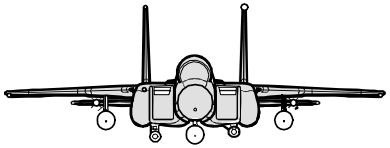
B-1



B-2



F-16

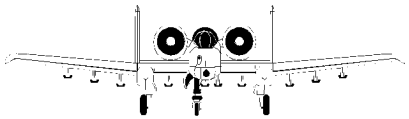


F-15E

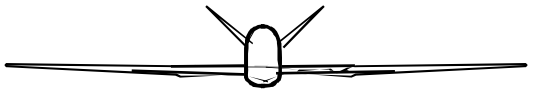


F-22A

NEW



A-10



MQ-9B

FUTURE



F-35

JPF Integration Occurs With JDAM

Initiatives

- JPF Hard Tgt Characterization – Gather JPF Survivability Data (>5K psi)
  - Phase I – Detonation Test & 2 Sled Tests (Complete)
  - Phase 2 – Eight Sled Tests (10K psi Tgts)
    - First Test Conducted Dec 07 – Successful
    - Second Test Conducted Jan 08 – Did Not Detonate
      - FA Conducted and Corrective Action Implemented
    - Third Test Conducted Jun 08 – Did Not Detonate
      - Fuze Damaged During Retrieval Limiting Ktr's Investigation; FA Inconclusive
    - Fourth Test on 4 Feb 09 – Successful
- Retractable Actuator Study
  - Testing Complete; Data Supports Increased Shock Endurance From 40kGs to 70kGs
  - Production Implementation Projected by Aug 09
- FZU-55 Pull Force Study – Excessive Pull Force Measured During LAT
  - Pursuing Coined Groove vs. Photo-Etched Groove Process
    - 78 Out of 79 Prototype Pulls Successful
    - Production Implementation Projected by Aug 09

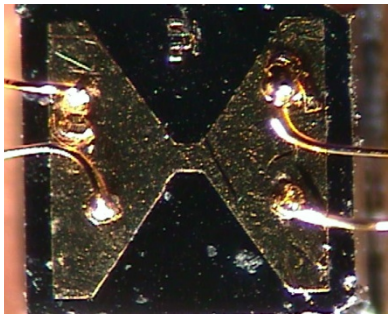
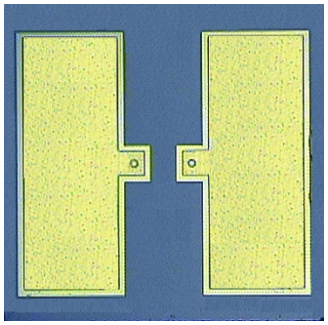
Operational Reliability Summary

Year	Total Expenditures	Total Reported Failures	Reliability	Relevant Failures	Reliability
2005	184	13	92.9%	5	97.1%
2006	368	3	99.2%	3	99.2%
2007	3,120	70	97.8%	43	98.6%
2008	1,818	51	97.2%	25	98.5%
2009	465	13	97.2%	2	99.6%
Cum.	6,179	150	97.6%	78	98.7%

Reliability > 95% Requirement

Summary

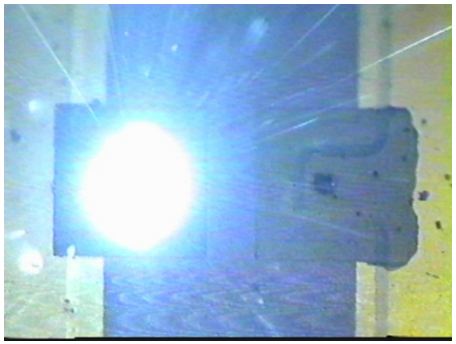
- Production Line Steady
  - 38,000 JPF Systems Placed in the Inventory
- Operational Reliability Stable (98.7% a/o Apr 09)
- Ongoing Initiatives
  - Hard Target Characterization
  - Retractable Actuator Study
  - FZU-55 Coined Groove Design Validation
- Working Lots 6-8 Negotiation Activities

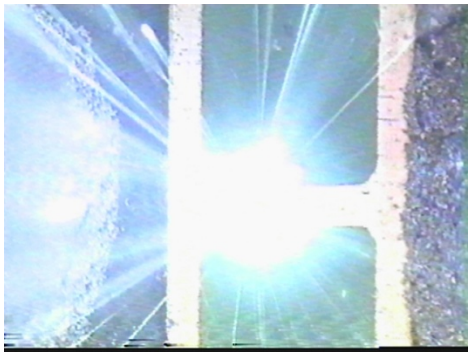




A Robust Planar Triggered Sparkgap Switch for High Power Pulse Applications

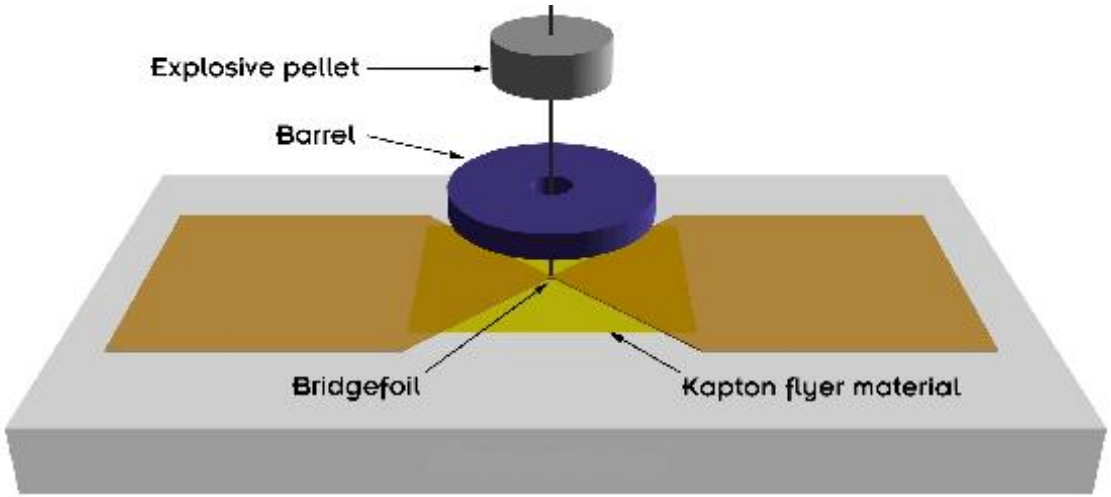
Thomas A. Baginski

Auburn University

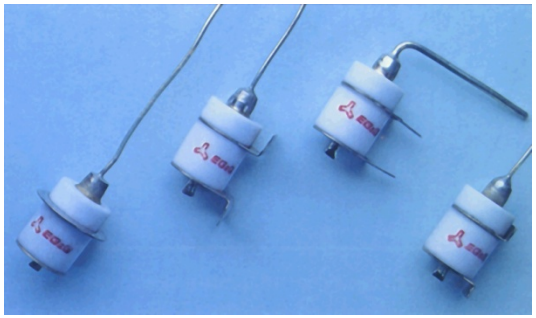


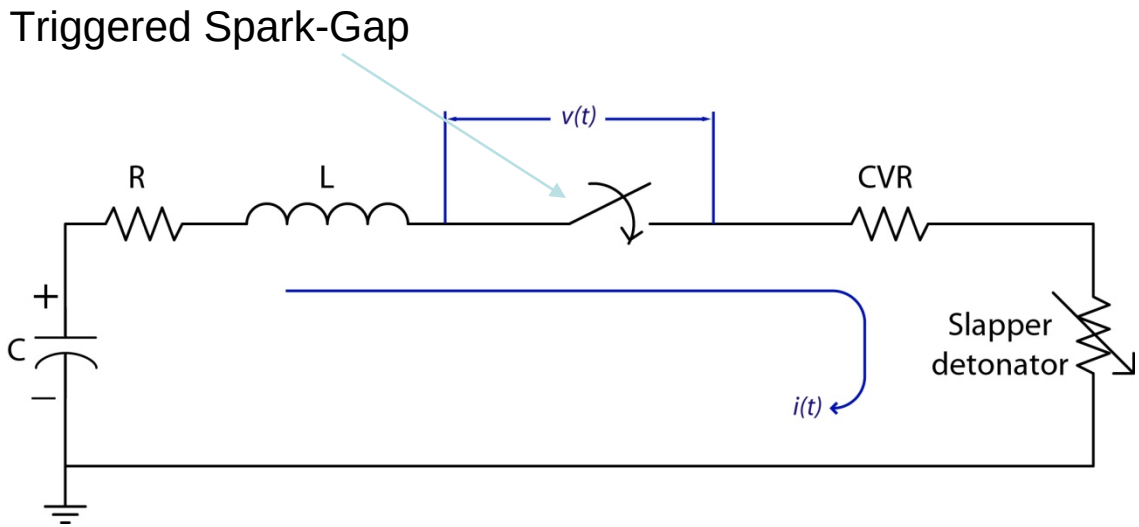


Chip Slapper Detonator



Typical Capacitor Discharge Unit (CDU)

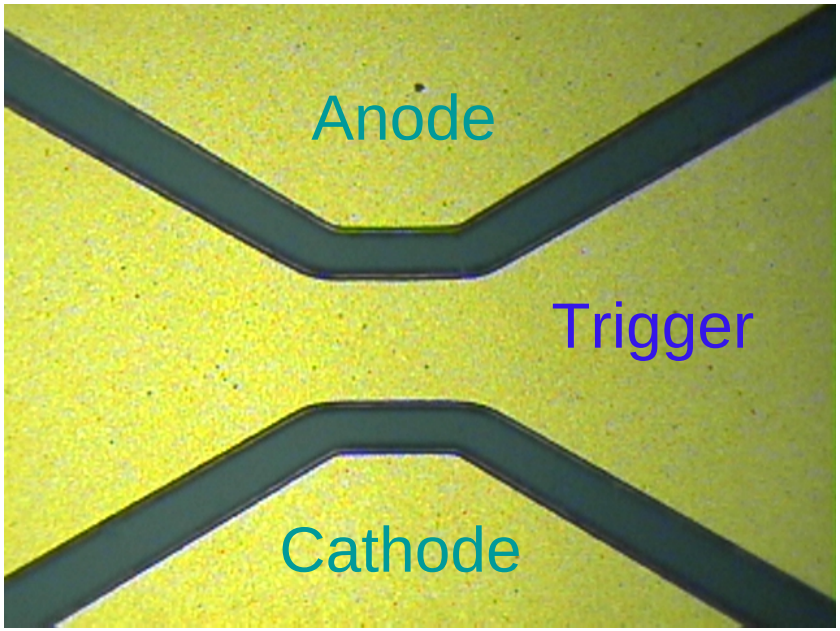




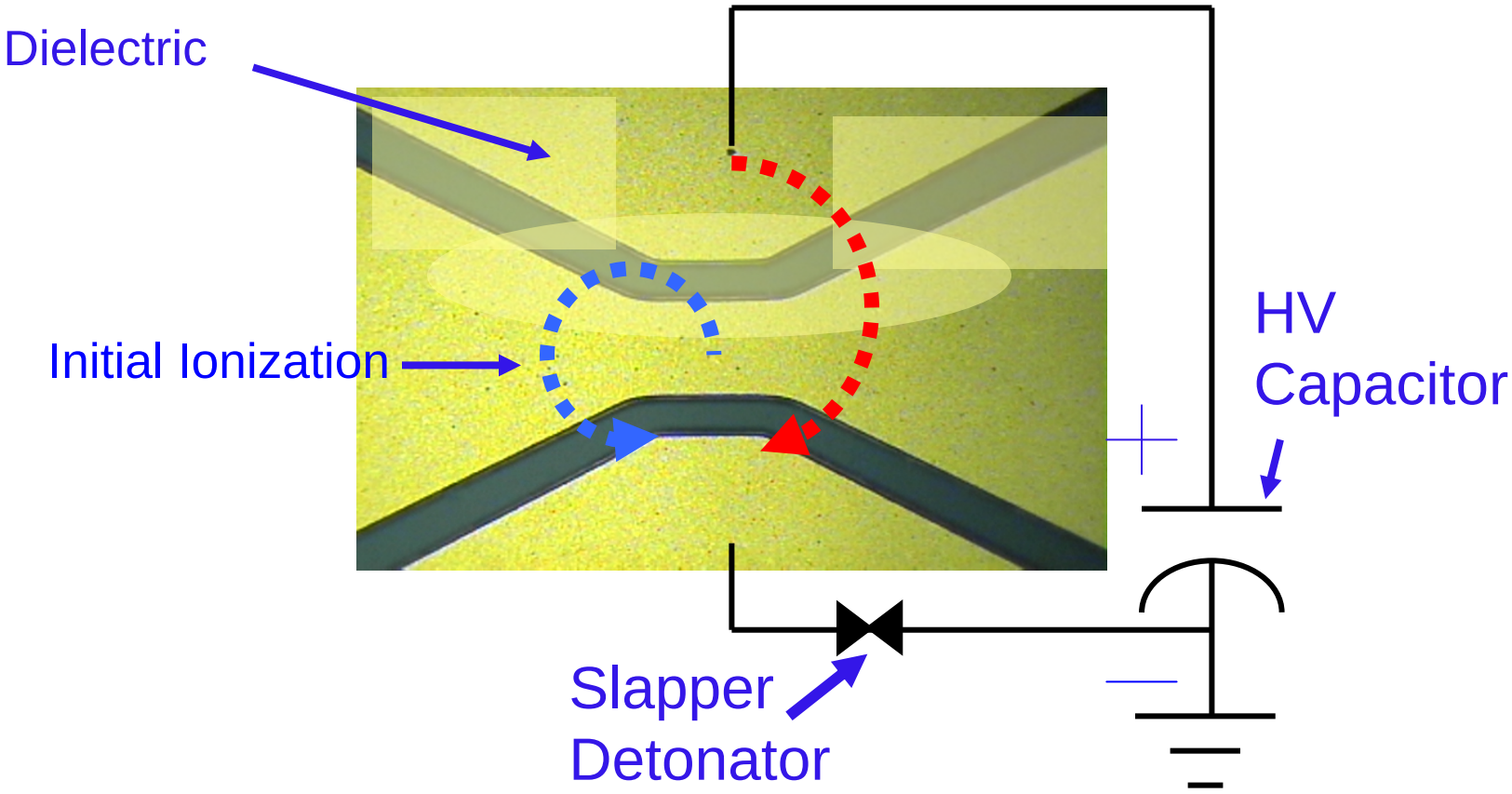
Switch Requirements

- Standoff voltage greater than 1500V
- Switch should allow fast discharge of a high voltage capacitor with a discharge time (τ) less than 100 ns.
- The switch should be capable of being actuated with a low voltage signal (i.e. <50V trigger pulse).
- Fabrication should employ a simple layout that allows direct integration into strip-line geometries (minimize parasitic impedances).
- Monolithic construction should be employed using conventional micro-electronic fabrication techniques to make the switch mechanically robust.
- No energetic compounds can be used in the construction of the switch.

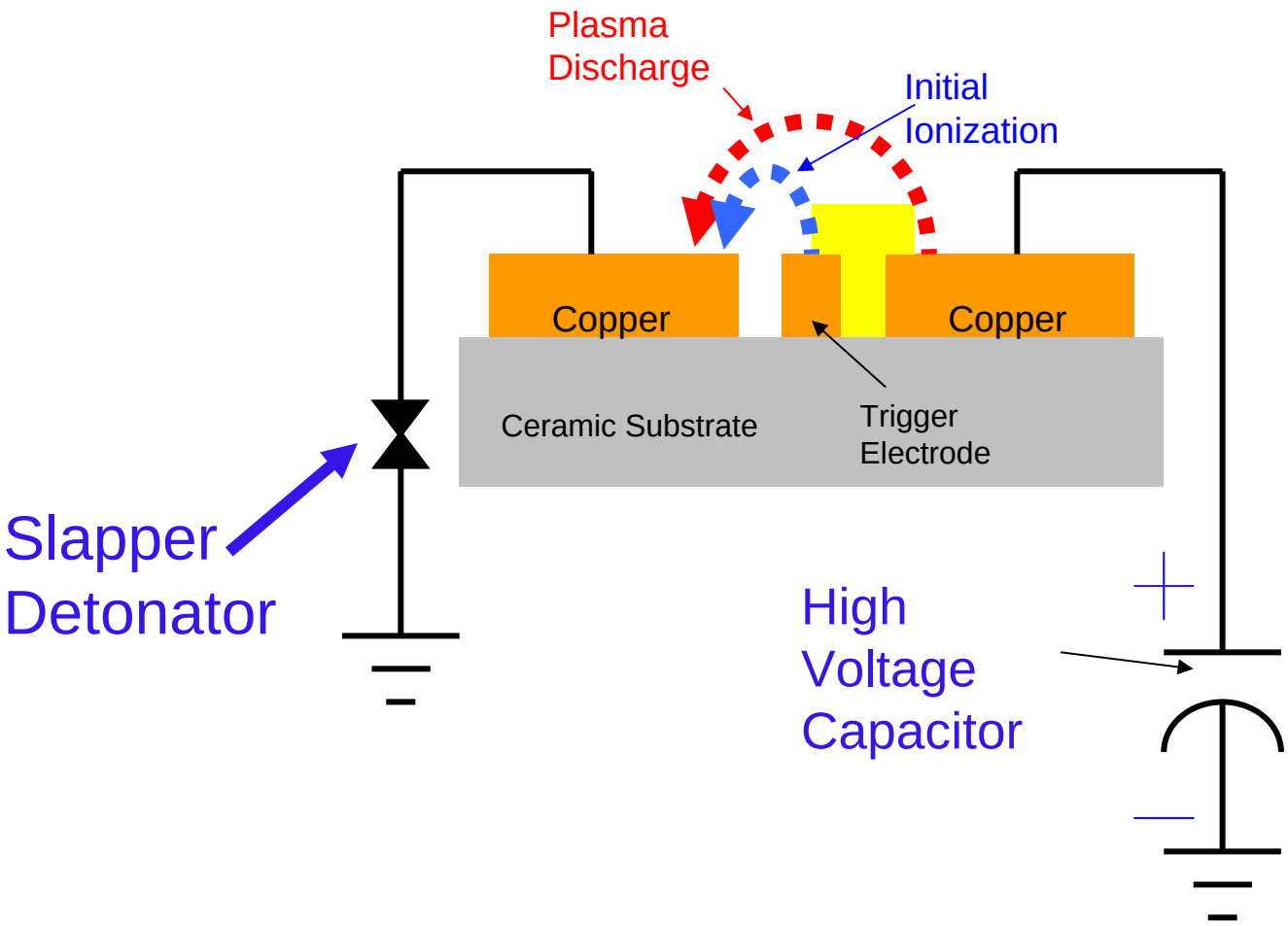
Planar **T**riggered **S**park-Gap Switch



Switch Actuation

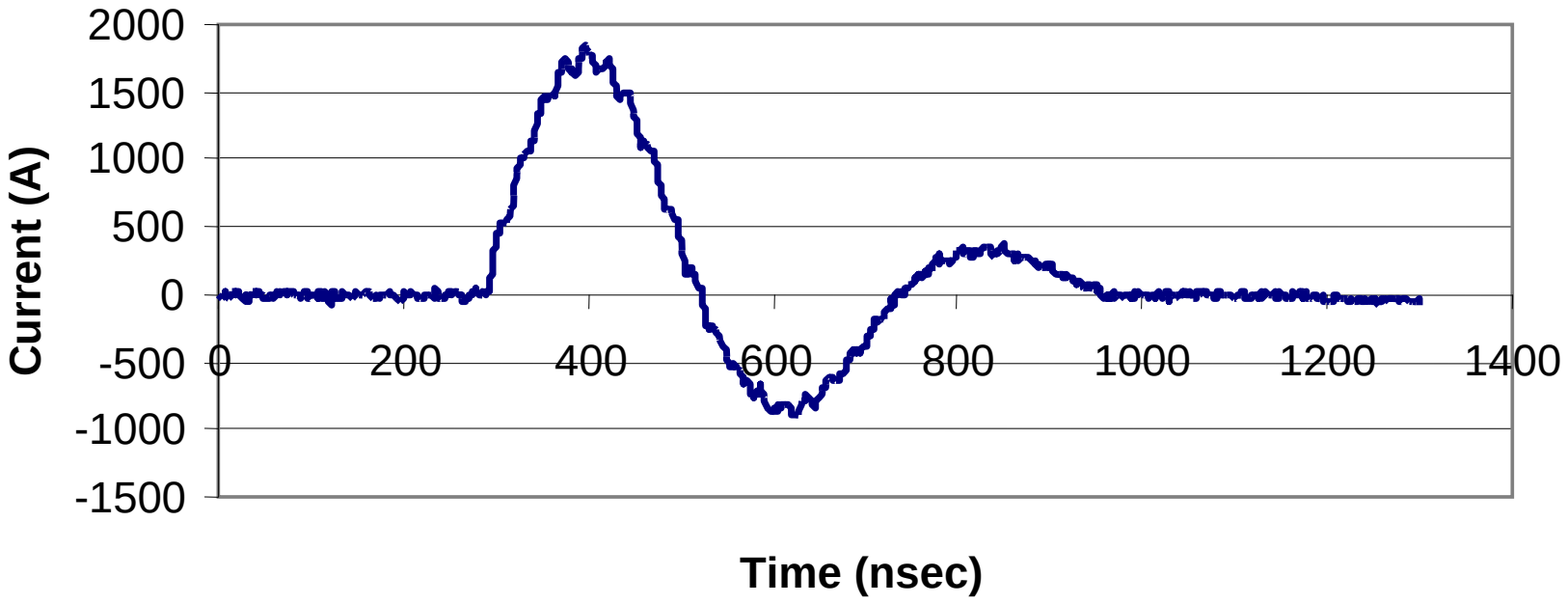


Switch Actuation

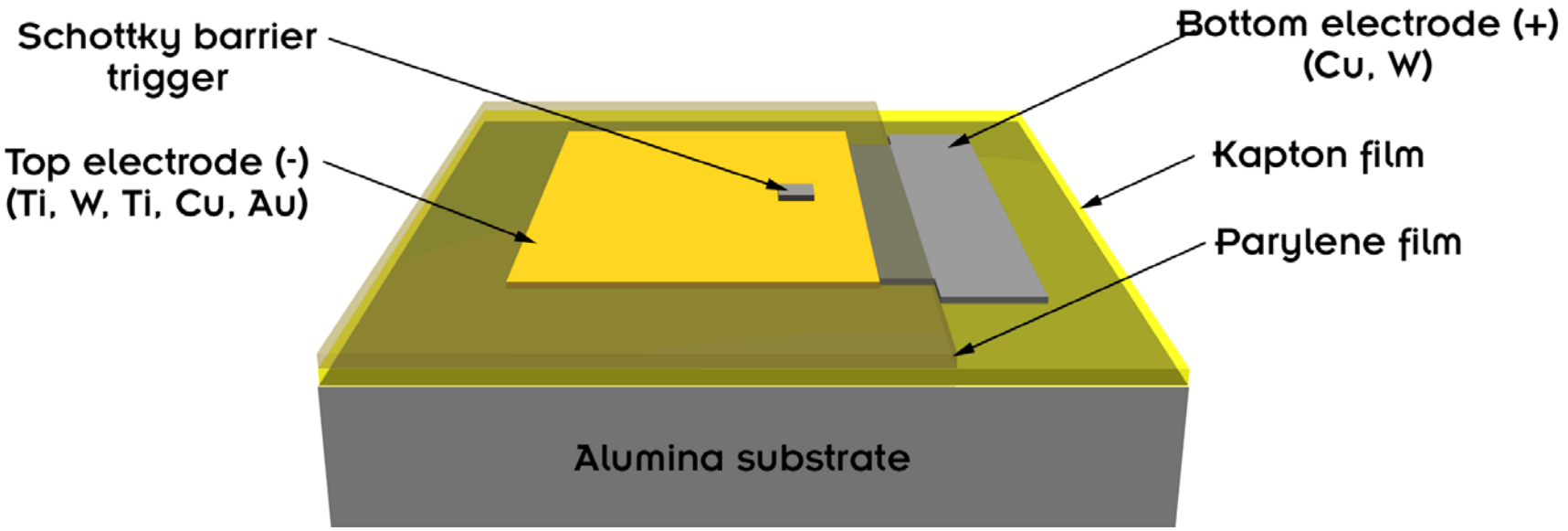


Ring Down (PTS Switch) C=.17uF, V=1000V,

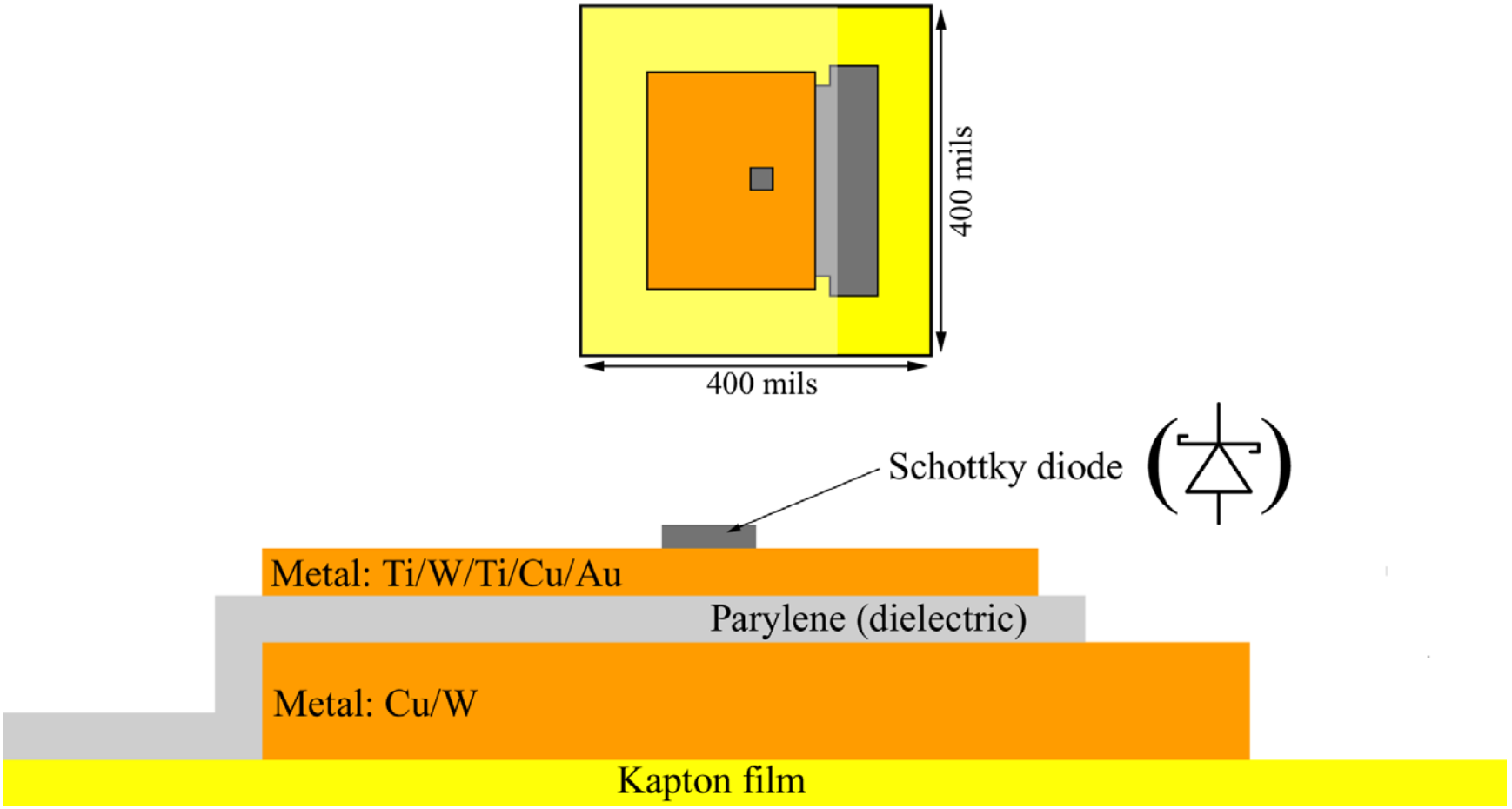
Test Load =.004ohm



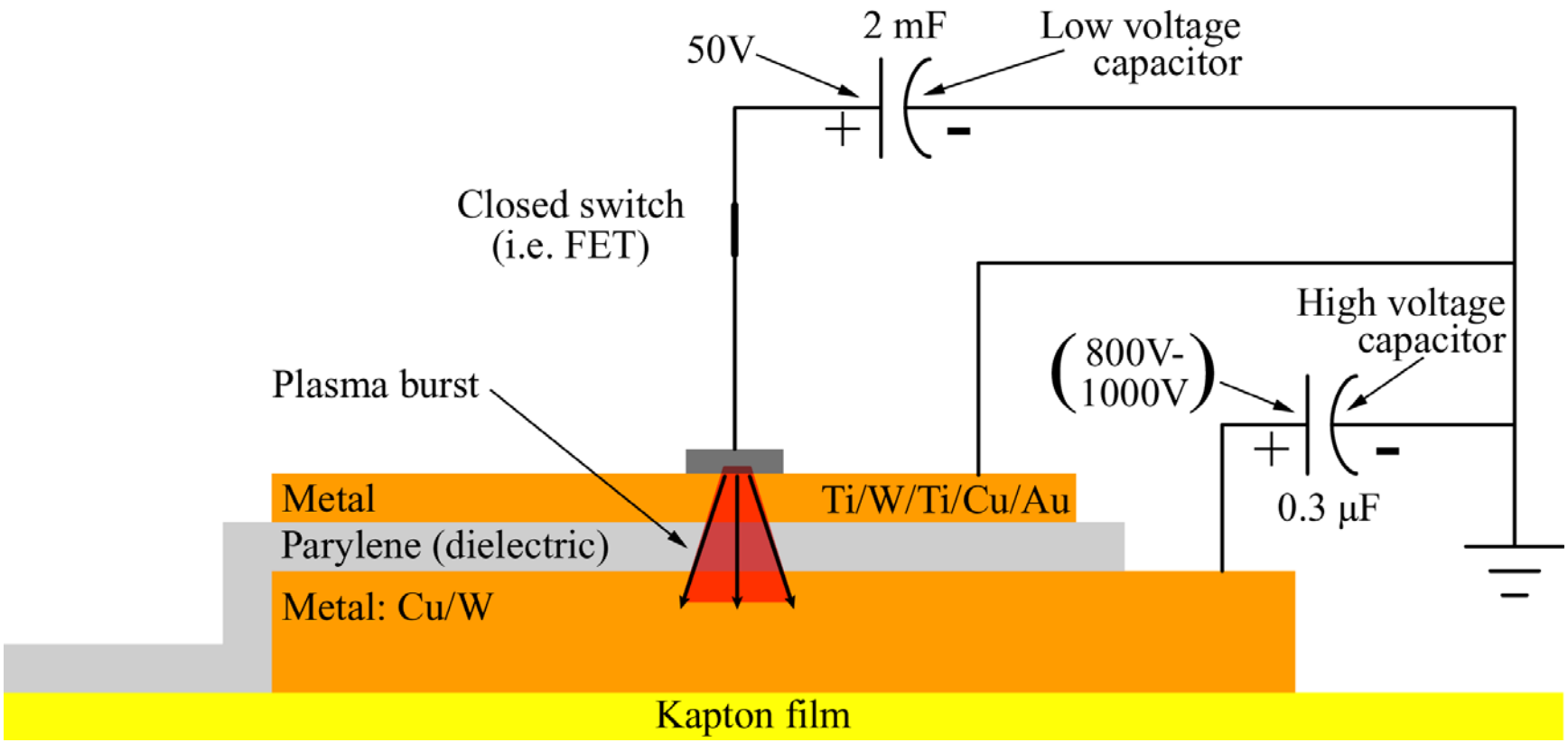
Parylene **S**hock **S**witch



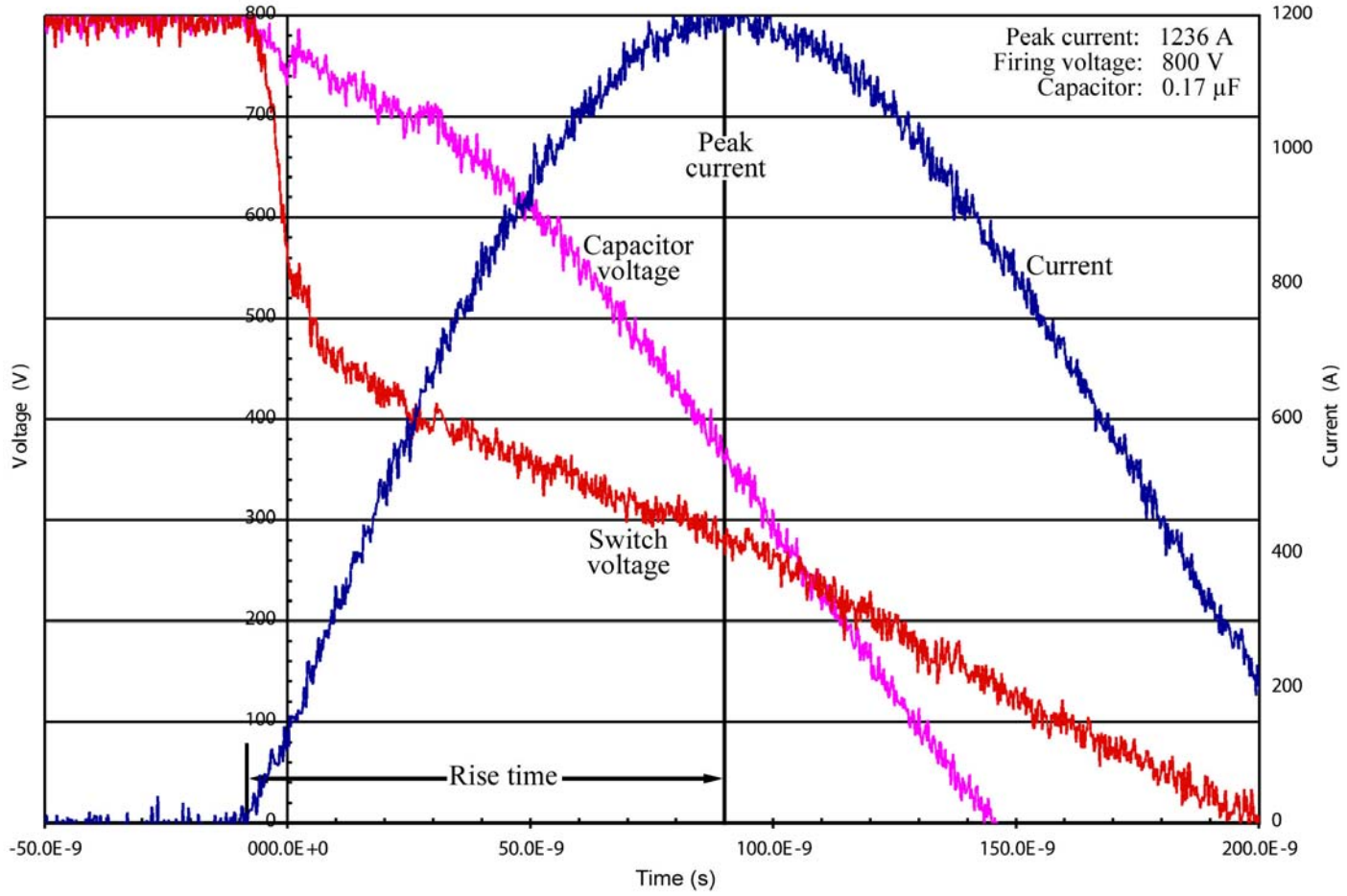
Schematic representation of shock switch.



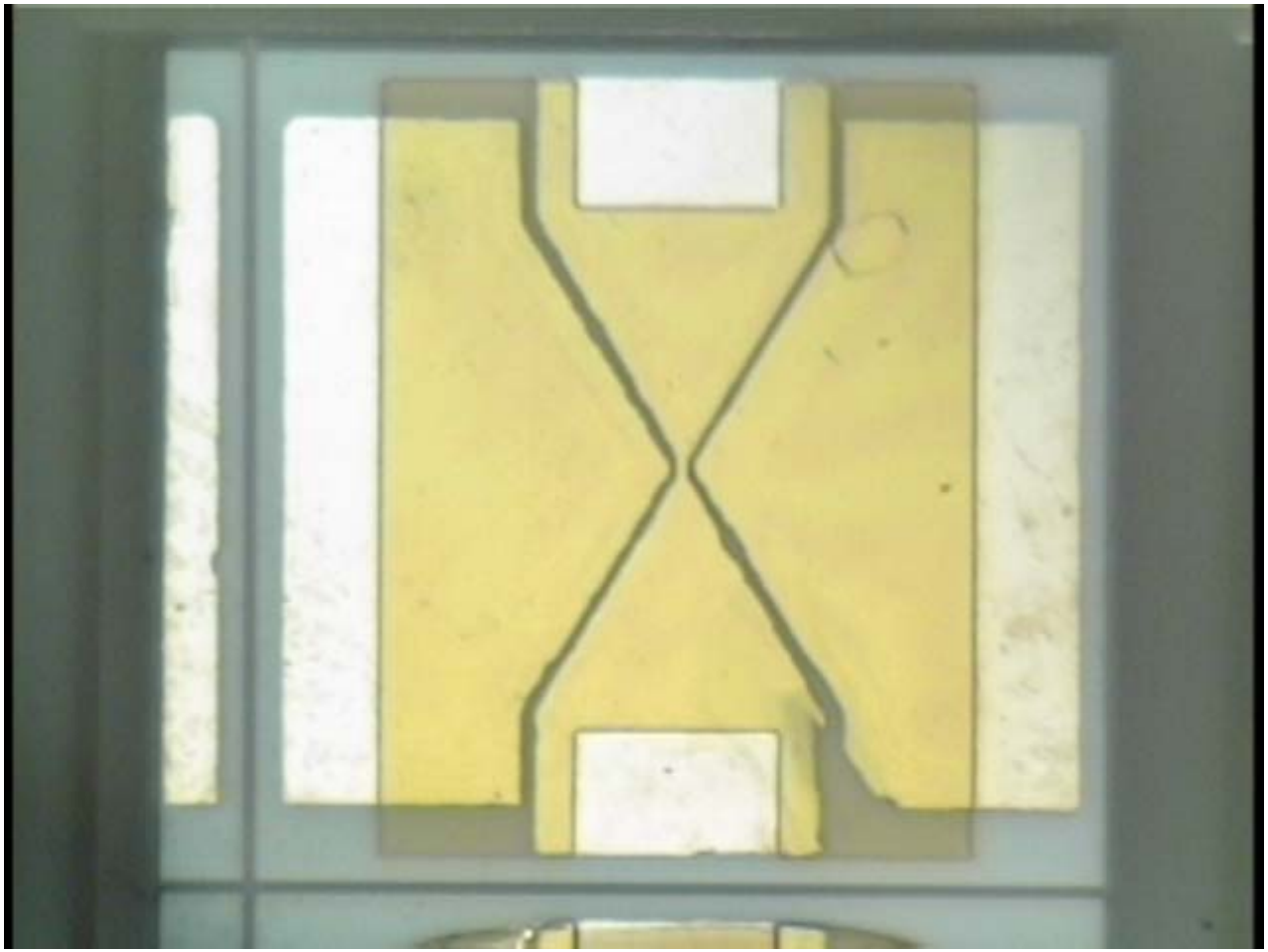
Schematic representation of switch actuation.



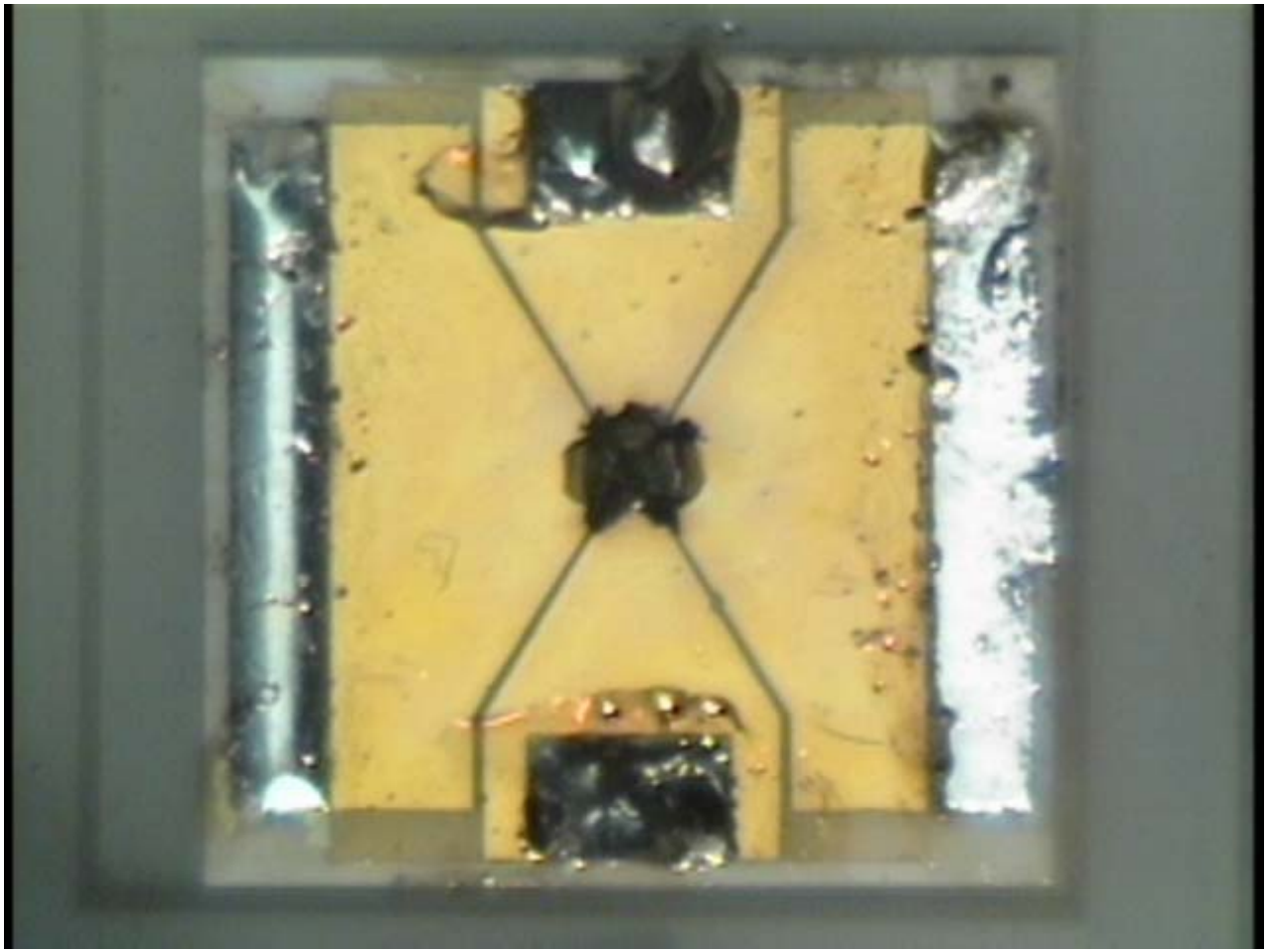
High voltage switch firing data obtained from a high speed digital oscilloscope. Traces are shown for the capacitor voltage, switch voltage, and switch current.



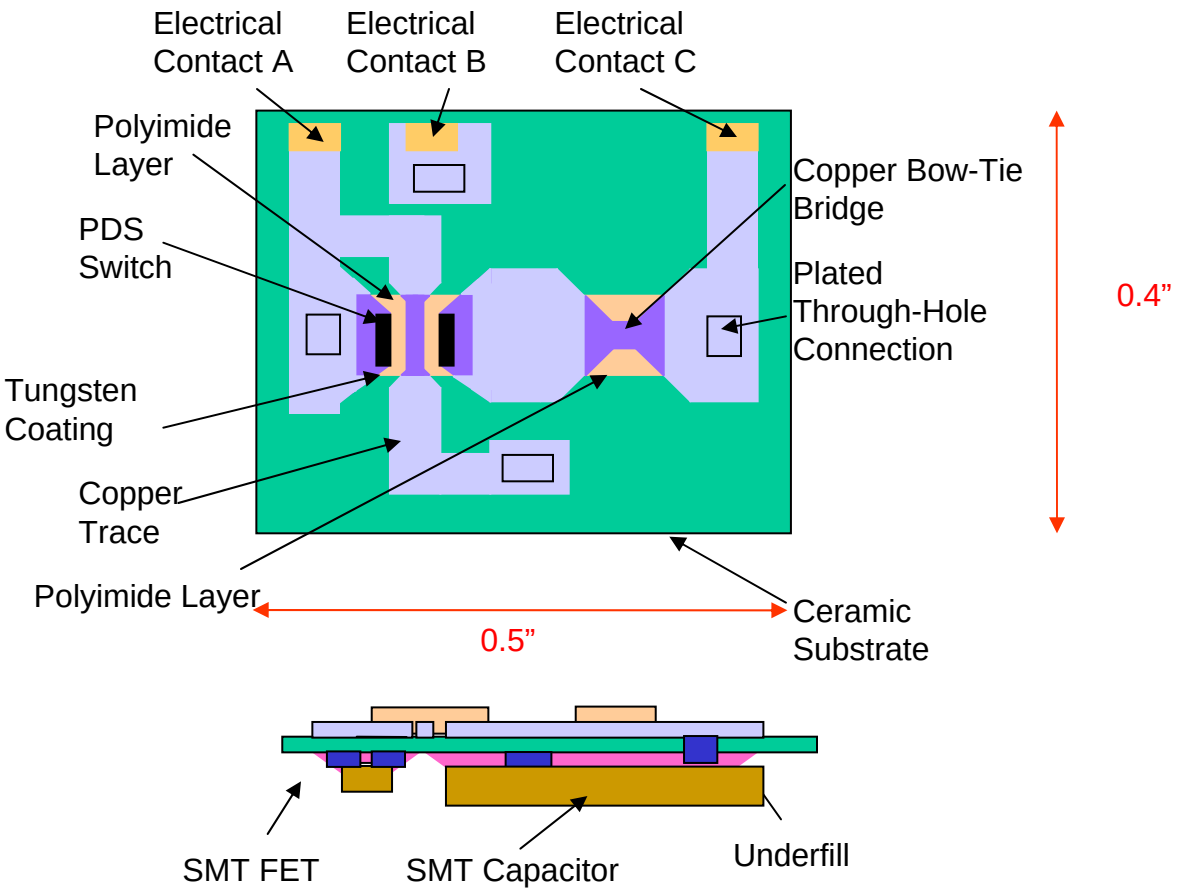
Planar **D**ischarge **S**witch (PDS)



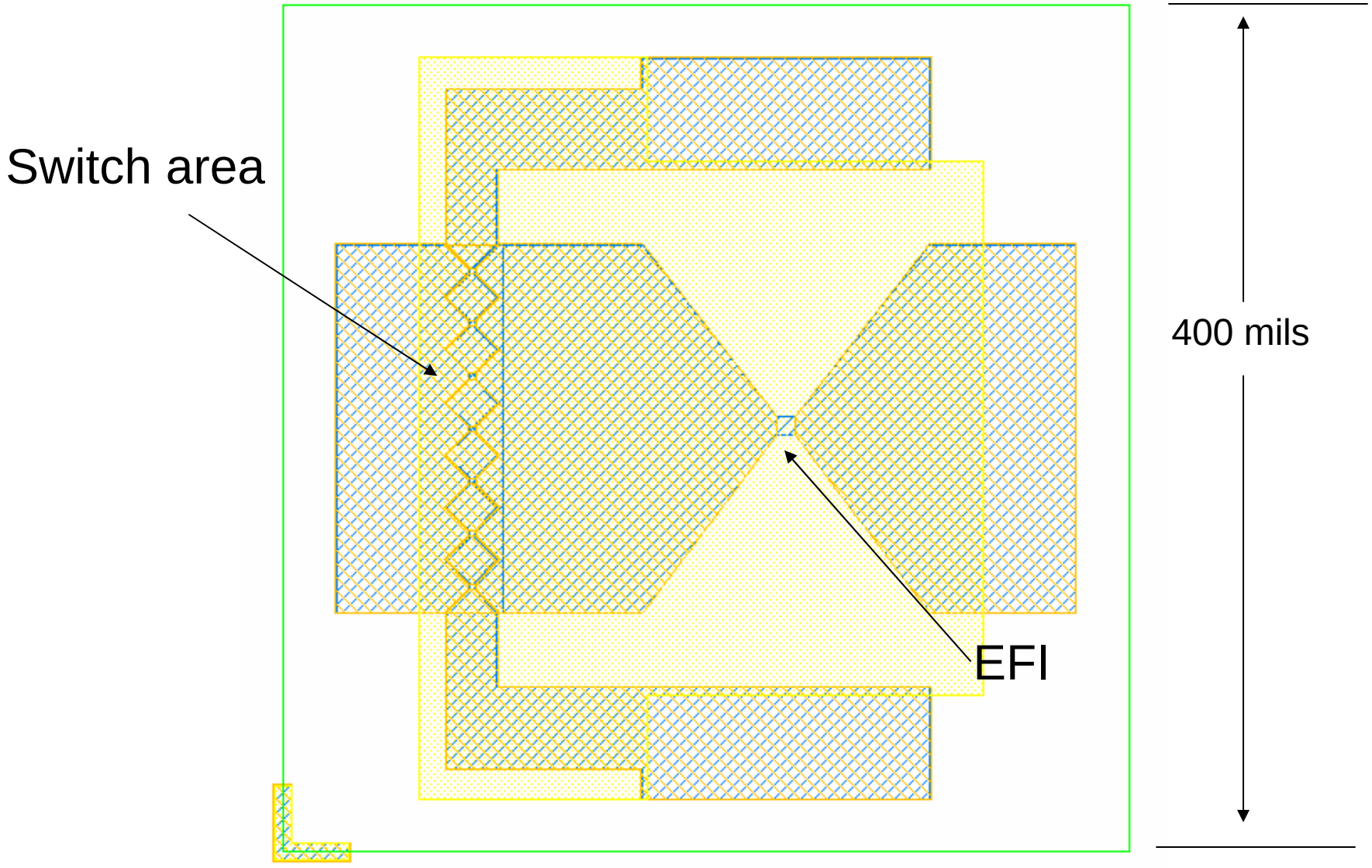
Fired Planar Discharge Switch



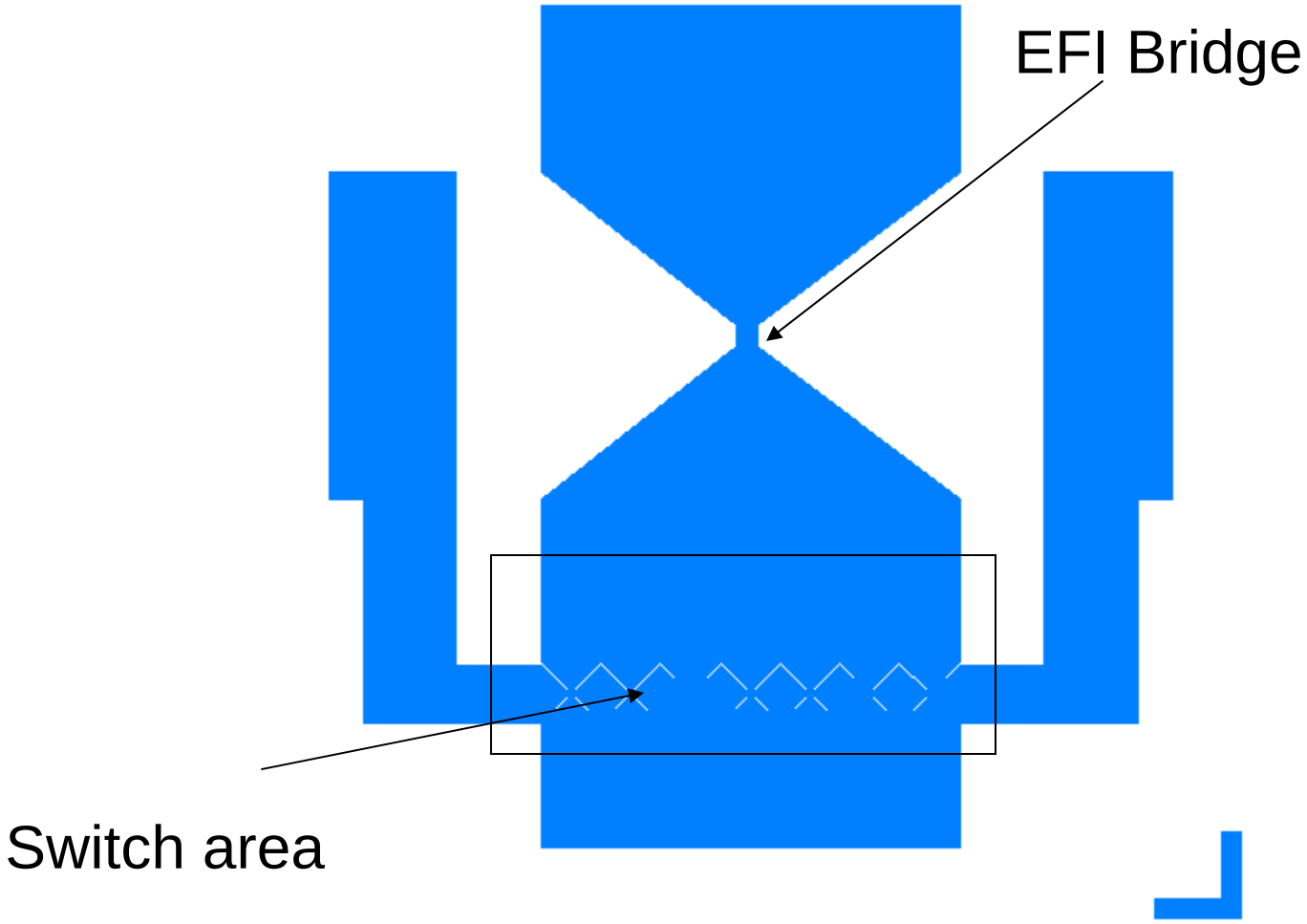
Miniature Fireset Concept with Planar Discharge Switch



PDS plus EFI with Common Substrate

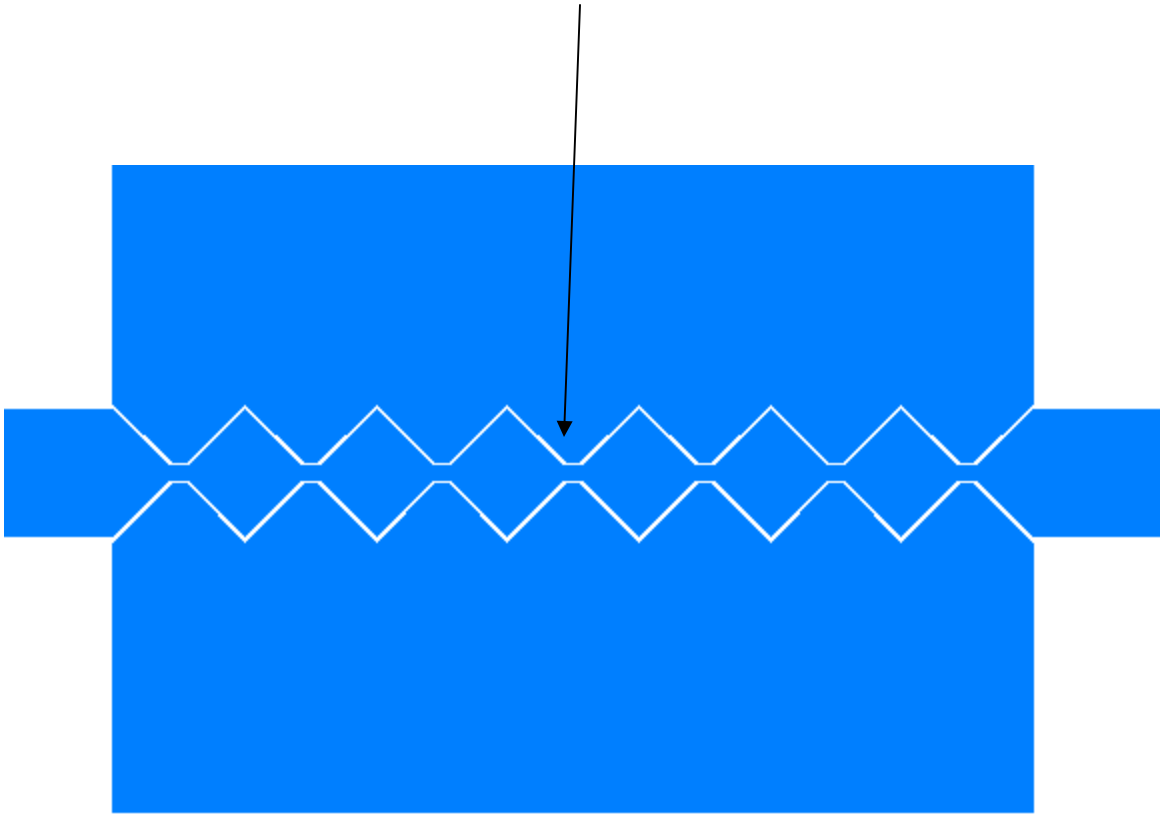


First level is patterned aluminum, bridge is standard size

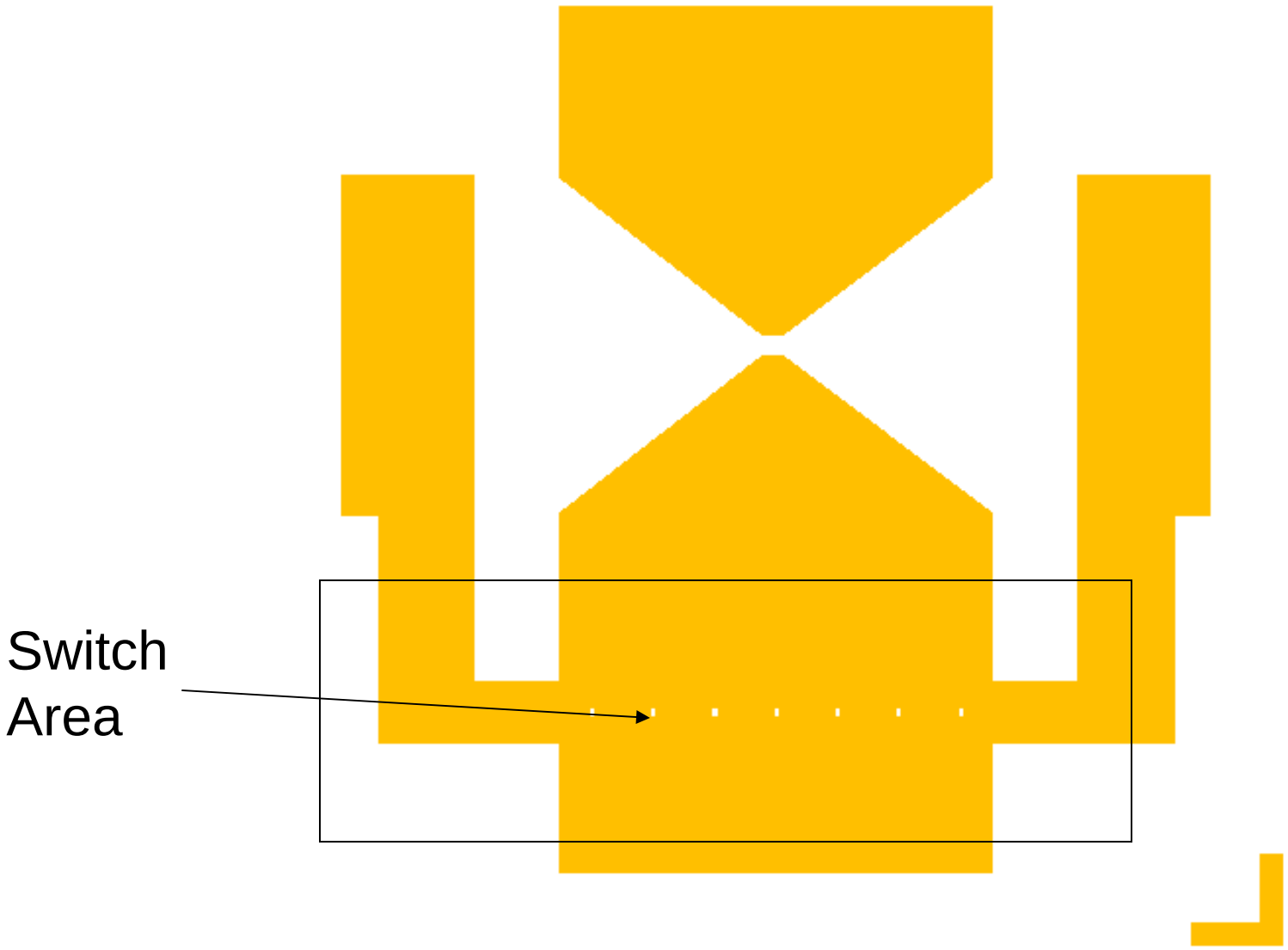


Zoomed view of “switch area”

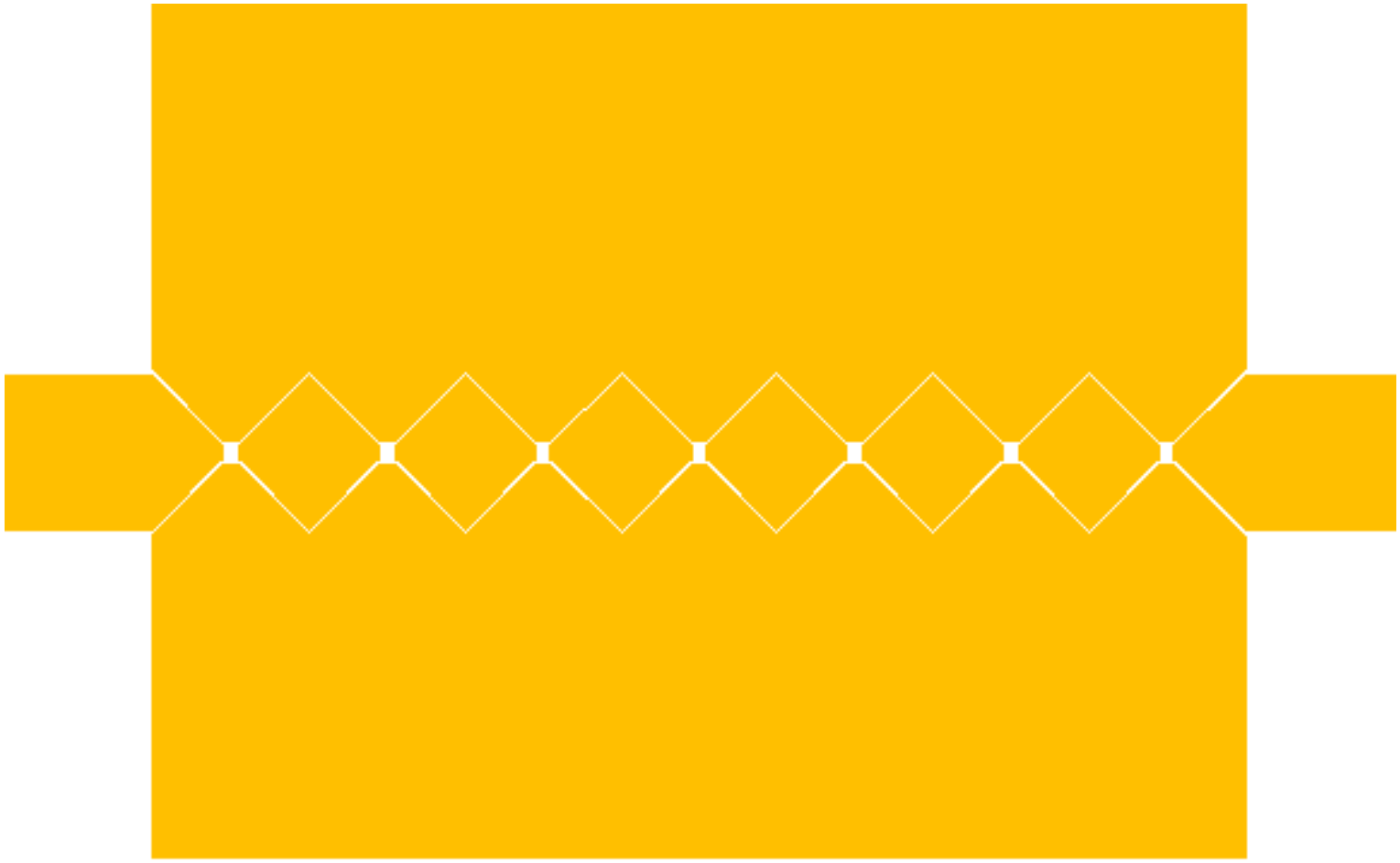
small bridges are 2.5mil x 2.5mil



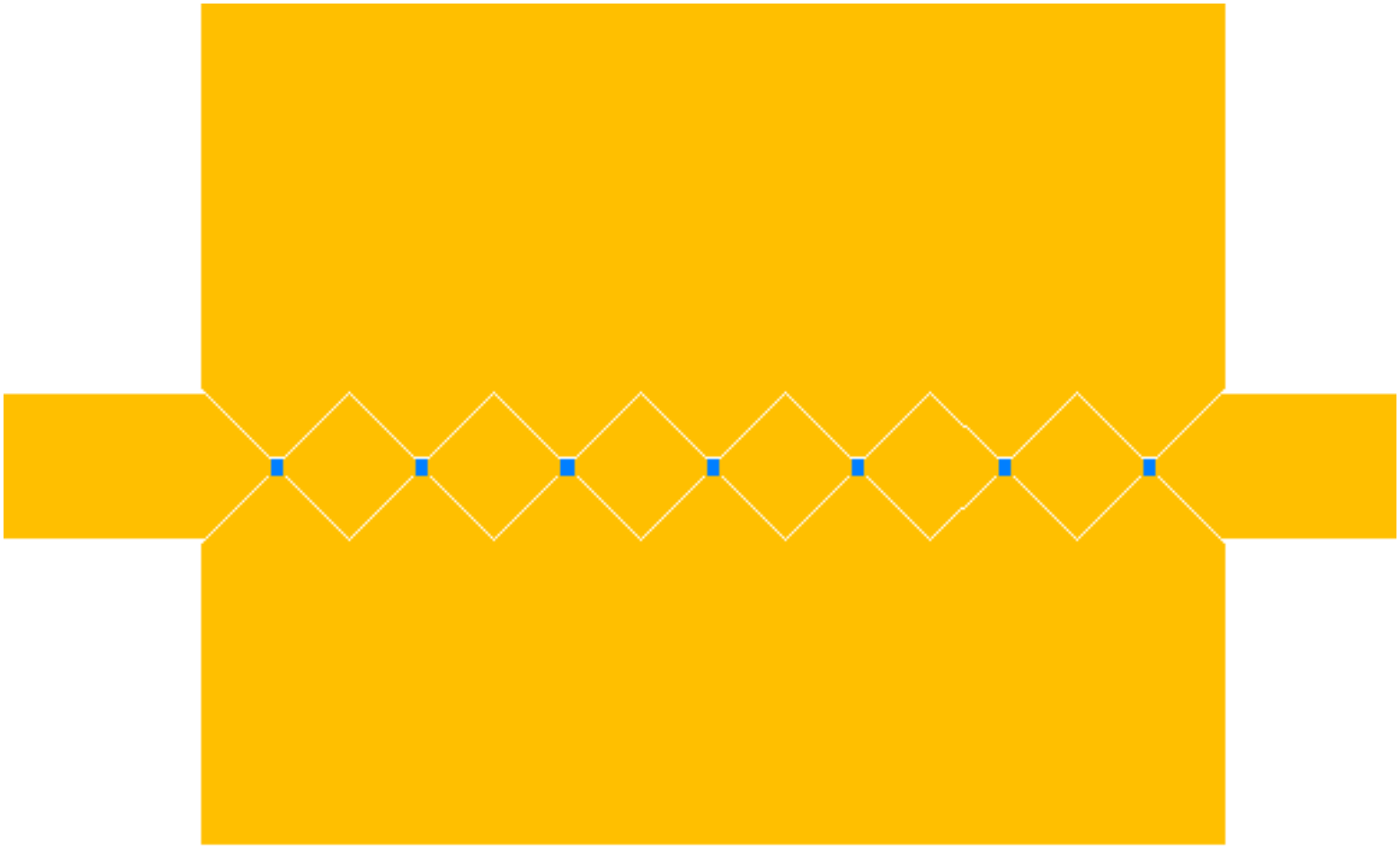
Liftoff layer for coating aluminum with Ti/Cu/Au



Expanded view of switch overcoat, gaps are ~ 15um, copper covers everything except Al bridges

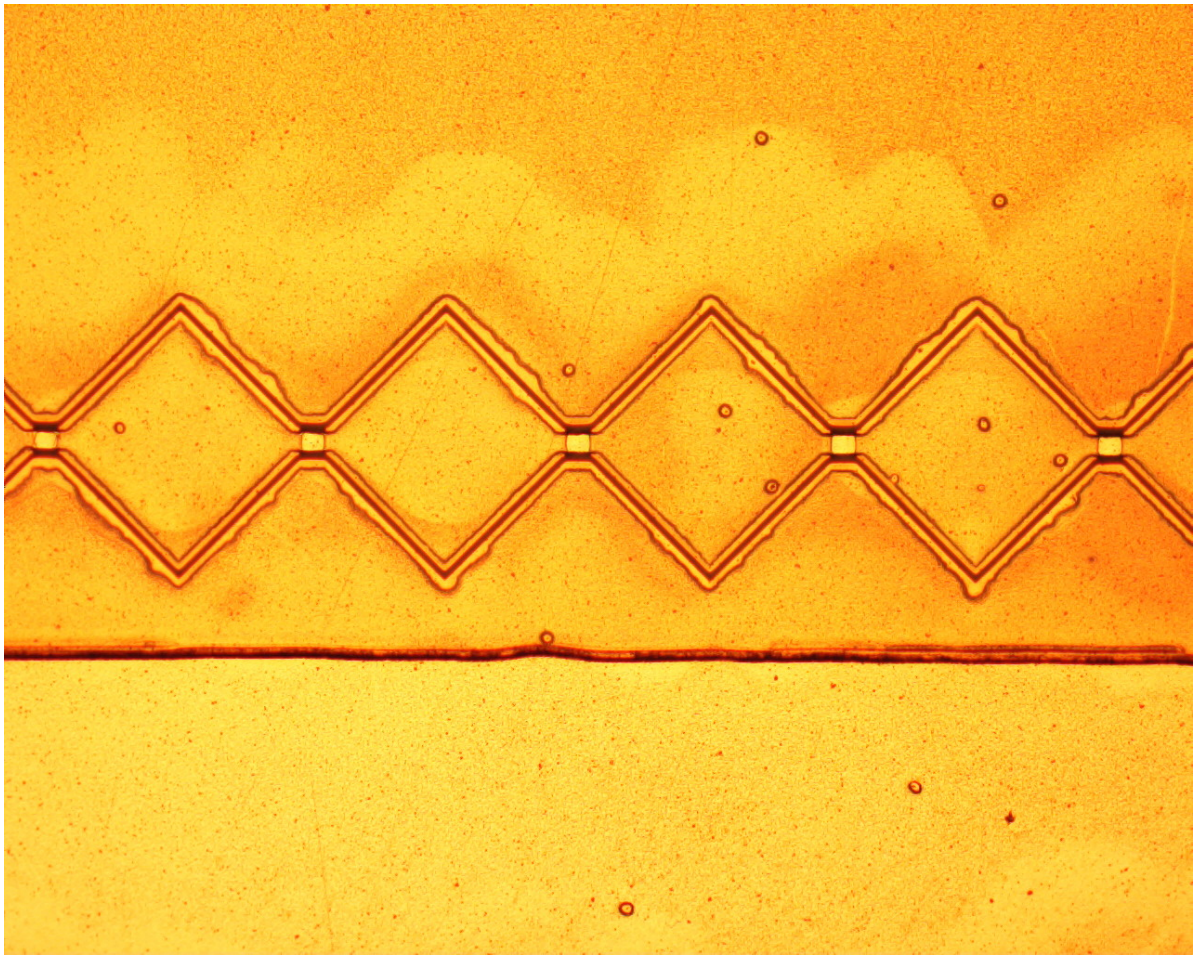


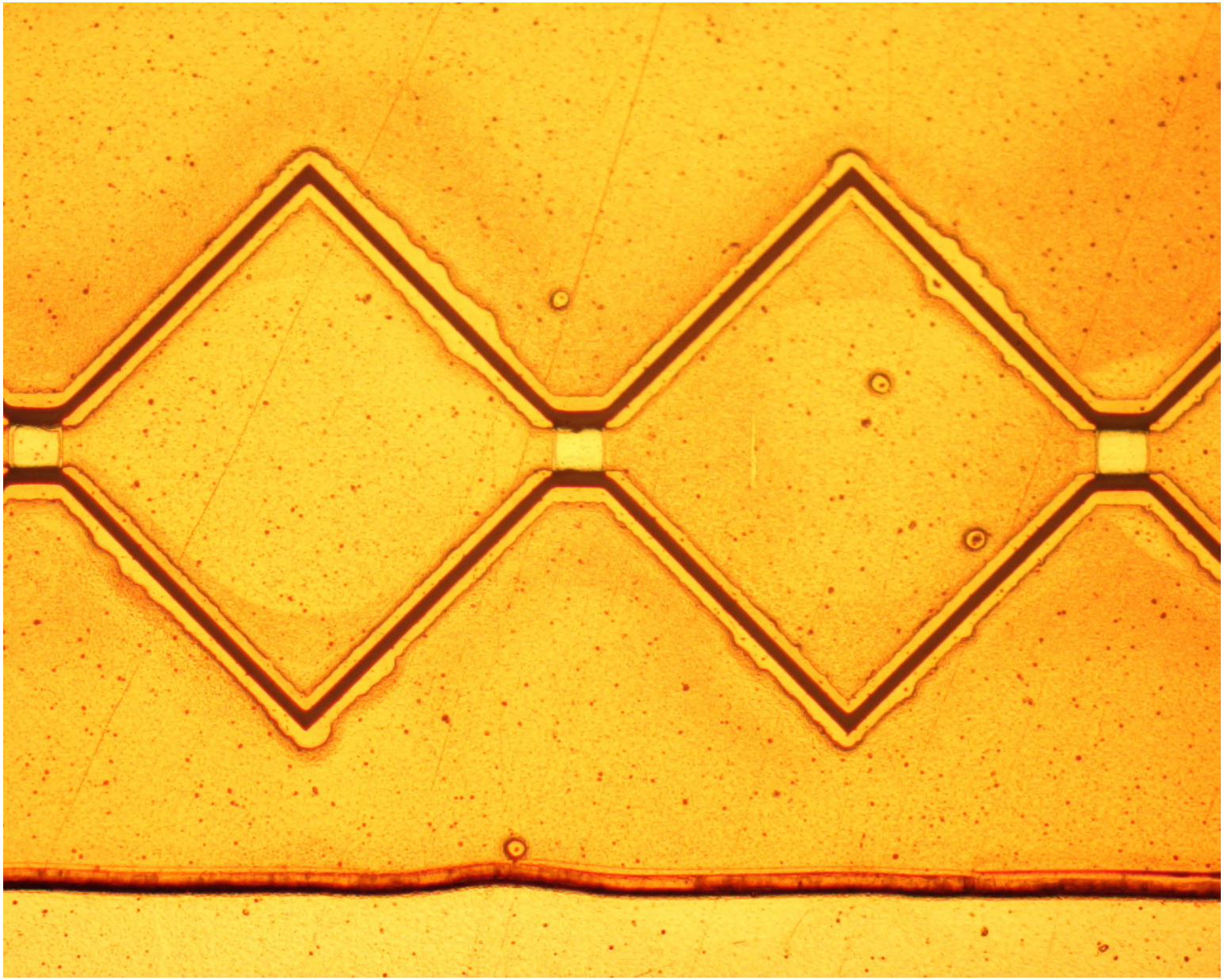
Blue is aluminum, orange is aluminum coated with Ti/Cu/Au

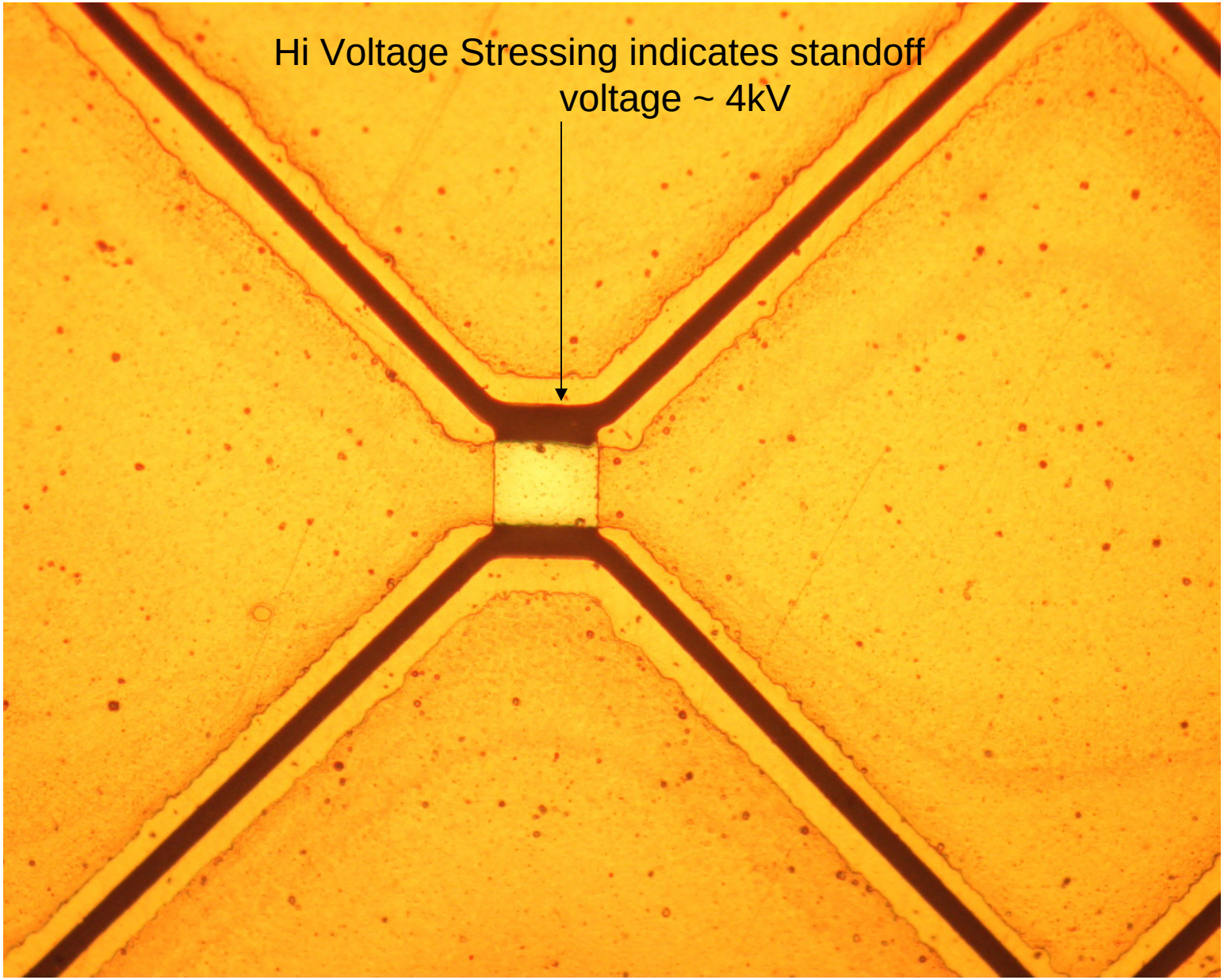


Polyimide layer

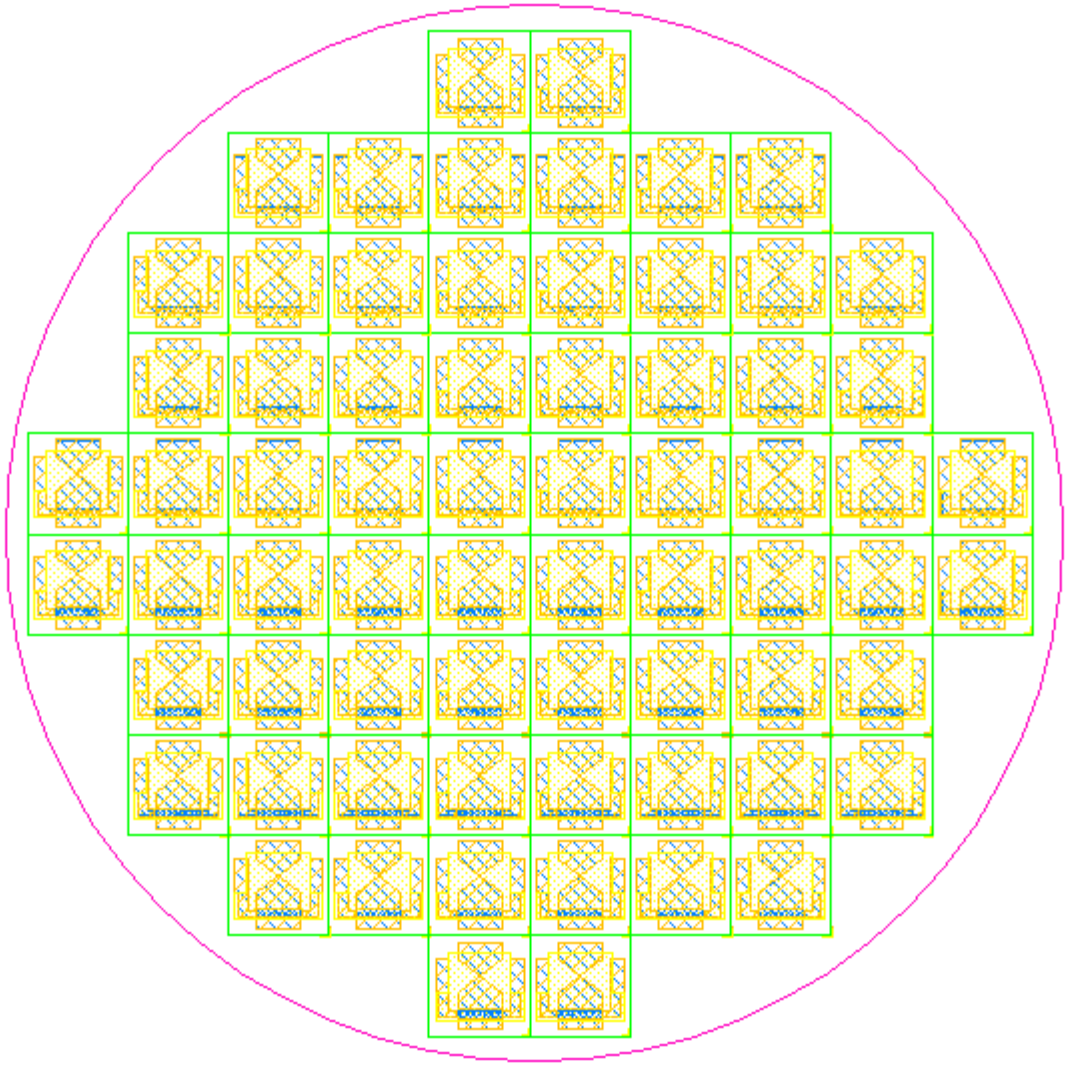
Switch after Ti/Cu/Au and Polyimide

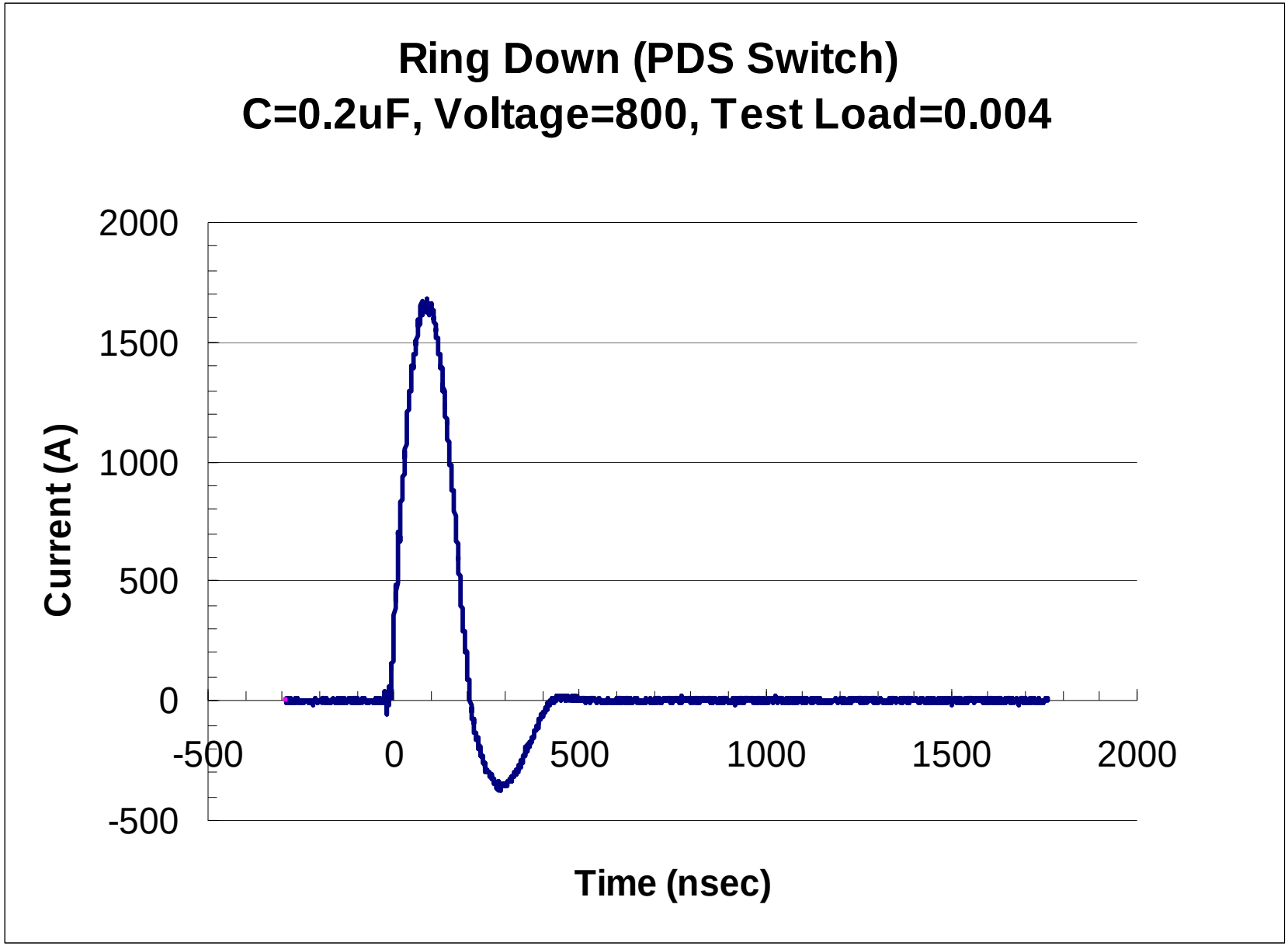




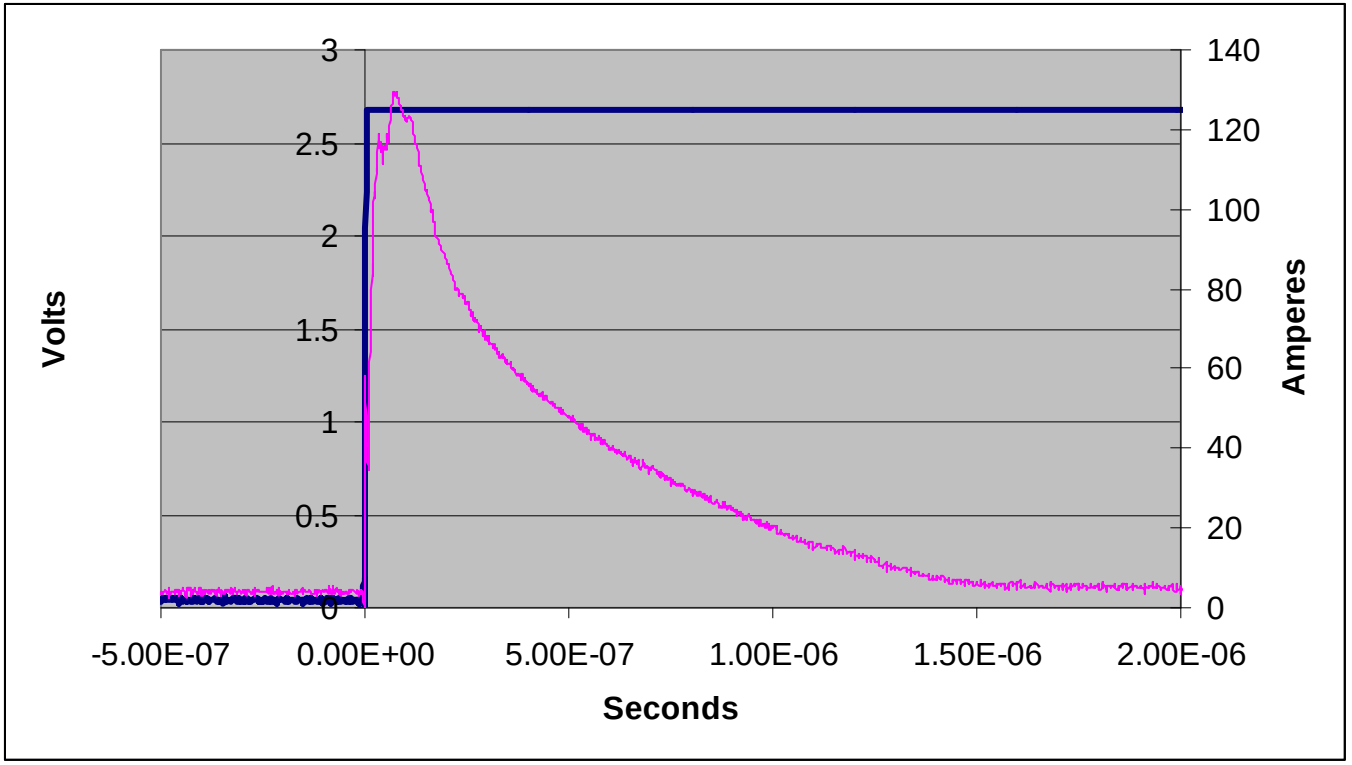

Hi Voltage Stressing indicates standoff
voltage ~ 4kV

68 die on typical 4 inch substrate

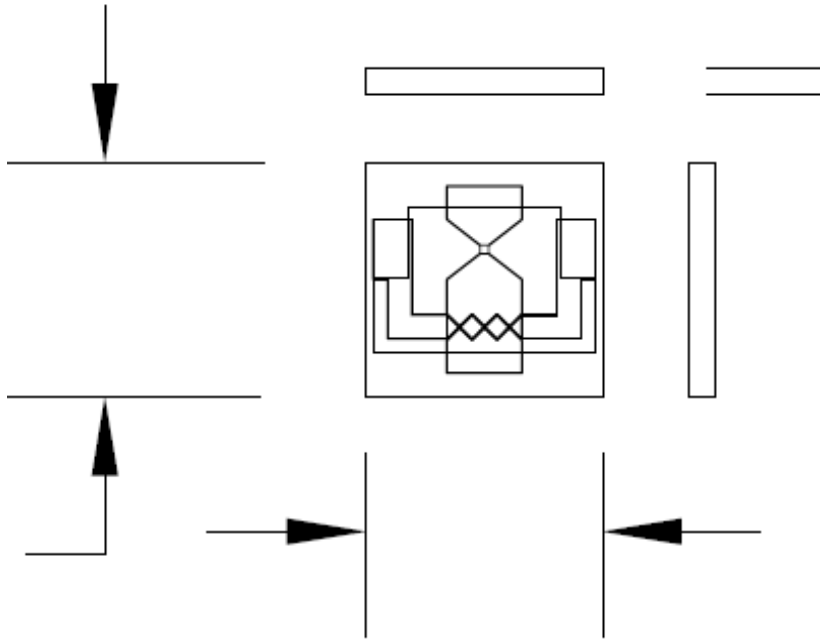



Ring Down (PDS Switch)
C=0.2uF, Voltage=800, Test Load=0.004
2000
1500
1000
500
0
-500
Current (A)
-500
0
500
1000
1500
2000
Time (nsec)

Jitter is repeatable and acceptable for typical EFI applications



Present Work
Reduce Size/Integrate on Standard Header



Conclusion

A novel one-shot switch has been introduced.

The structure is simple to construct using standard microelectronic processing techniques.

The device is easily integrated into flat stripline geometries

Device successfully functioned slapper with HNSIV

JUNGHANS microtec





High Fuze Reliability and Safety Today and in the Future

Frank Kienzler
Karl Kautzsch

53rd Annual Fuze Conference
May 19 - 21, 2009 – Lake Buena Vista, FL
"Next Generation Fuzing - Maximum Advantage for the Warfighter"

Company Presentation

JUNGHANS microtec

- **A global leader in the field of ammunition fuzes and S&A devices**
- **Full range of products**
- **Key competences in**
  - Fuzing technologies
  - Micro-technologies
  - Ammunition electronics





UN-Protocol V:

JUNGHANS microtec

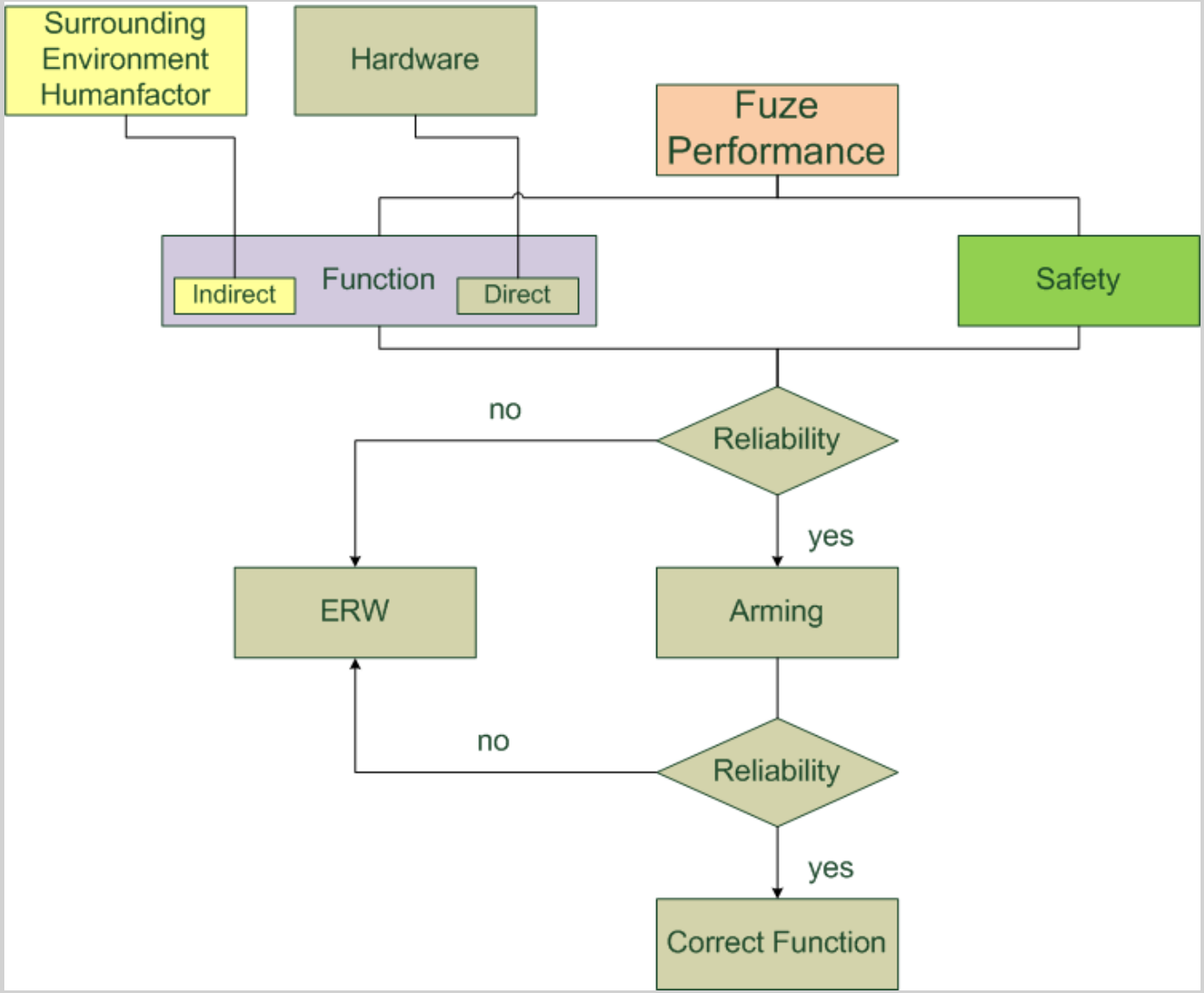
Extraction UN-Protocol V:

OBJECTIVES

The Protocol recognizes the serious post-conflict humanitarian problems caused by explosive remnants of war and addresses post-conflict remedial measures of a generic nature in order to minimize the occurrence, effects and the risk of explosive remnants of war.

Next to general regulations to reduce the hazard of explosive remnants of war Protocol V covers the commitment to mark and to dispose of conventional unexploded ordnance devices. Furthermore the function reliability of munition should be improved on a unsolicited basis. Protocol V is an important amendment to the UN weapon convention.

Fuze Performance



Explosive Remnants of War (ERW)

- High fuze reliability decreases ERW

- Interactions between Fuze safety and Fuze reliability
  - Fuze function depends on reliability
  - Fuze handling depends on fuze safety
  - Fuze safety is defined in STANAG 4187
  - Till the fuze arming safety is relevant
  - After arming function reliability is relevant

- Modern fuzes should have high reliability and high safety

Mechanical Mortar Fuzes (in service)
as an example for high reliability

JUNGHANS microtec

MTSQ DM93 (M776)



More than 4.5 mio. produced

PD DM111A4



More than 12 mio. produced

Initial Situation:
MTSQ DM93 - Mechanical Time Super Quick



type classified in USA as M776

Weapon

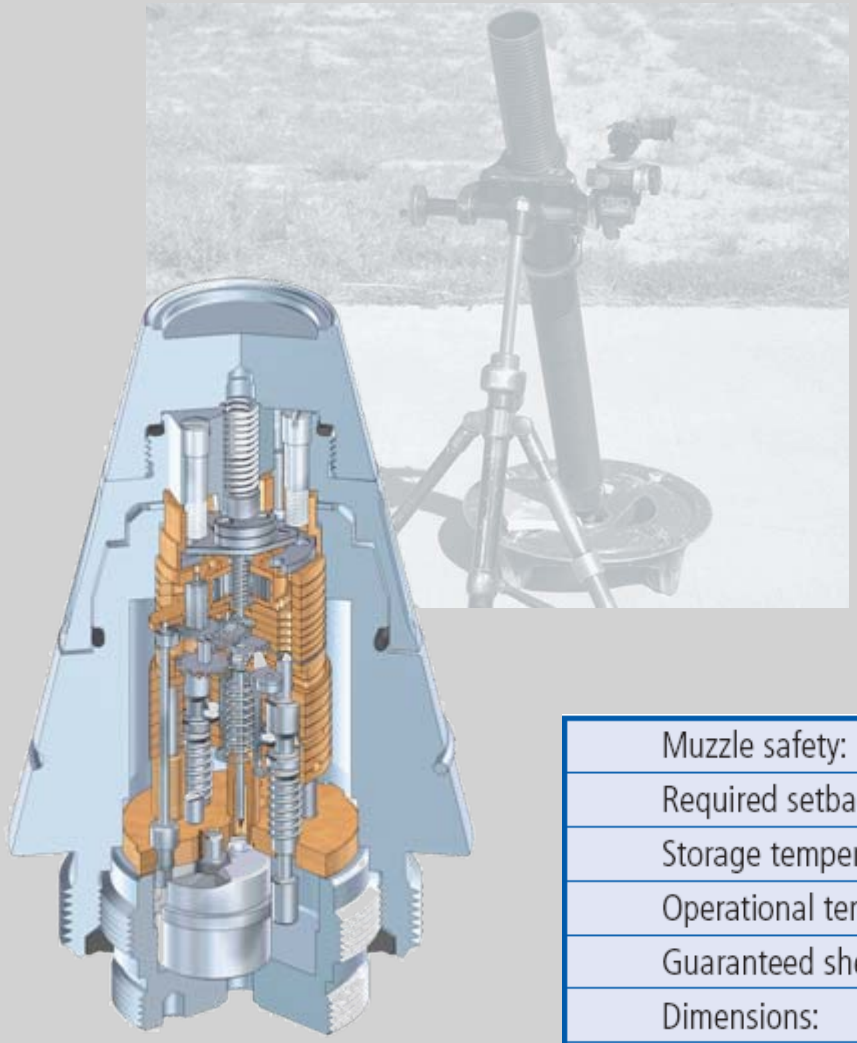
- all common smooth bore mortars (51 mm - 120 mm)

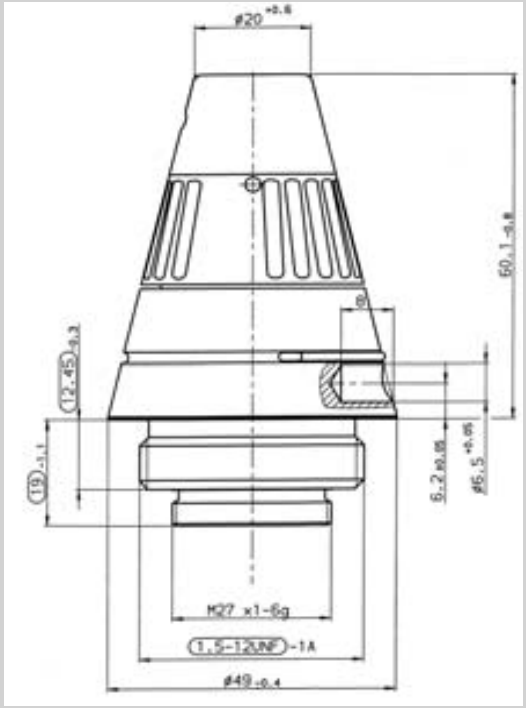
Further information

- more than 4.5 million units produced
- numerous customers including UK, Germany, Switzerland, USA (M776 and variant M772) and Canada
- tailored to customer requirements: more than 50 variants available (3gr or 5gr expulsion charge, MT or MTSQ, 54sec. or 67sec. ,…)

Initial Situation:
MTSQ DM93 - Mechanical Time Super Quick

JUNGHANS microtec





Muzzle safety:	≥ 40 m (≥ 0,8 s)
Required setback for arming:	≥ 650 g
Storage temperature range:	-54°C to +71°C
Operational temperature range:	-46°C to +63°C
Guaranteed shelf life:	10 years
Dimensions:	STANAG 2916
Weight:	225 g
Setting time	6 to 54 s (67 s)

compliance with MIL-STD 331 B

DM93 Fuze Family Lot Acceptance Tests (LATs) since 2006* as an example for high reliability of in service fuzes

JUNGHANS microtec

- 2006: LATs 1,038 / 0 (1,038 firings, 0 failures)
- 2007: LATs 668 / 0
- 2008: LATs 432 / 0
- 2009: LATs 200 / 0

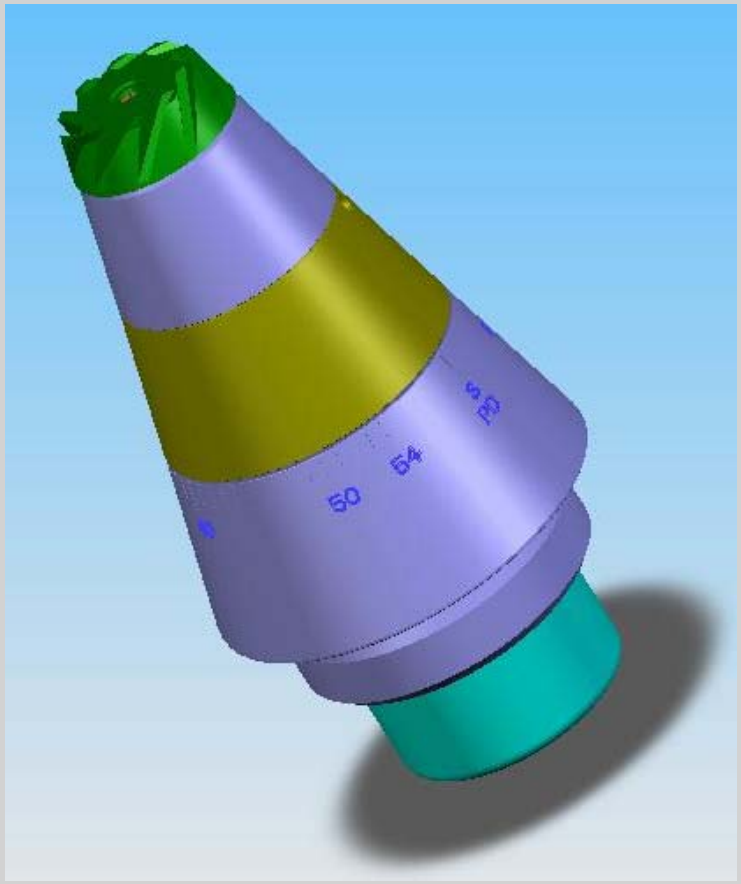
- Total: 2,338 / 0

- These LATs represent a production of more than 750,000 Fuzes

*** 2006: start of electronical documentation**

JUNGHANS microtec

Design DM93-S:





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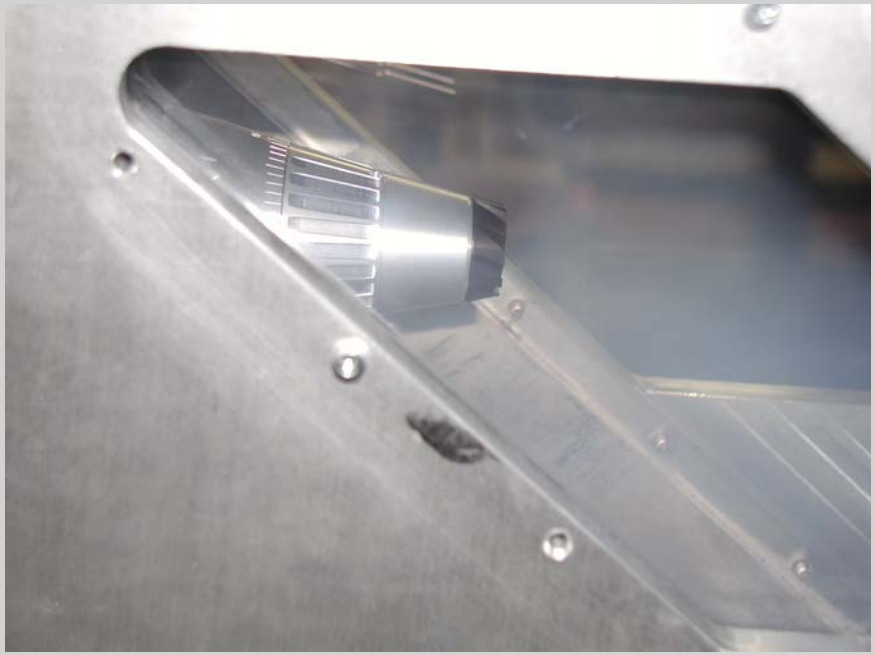
Concept DM93-S:

- MTSQ DM93 modified with a 2nd Safety Criteria
  - Fuze adapted with an external wind wheel and a centrifugal system
  - Creating a spin relation w.r.t. airflow in a non spinning munition
  - A 2nd Double Bolt System implemented to pre arm and unseal the System
  - For Arming the Centrifugal System needs 7.000 rpm



- Advantages
  - Fuze need no Safety Pin
  - Closed System
  - Fuze need no additional Cover (Protection against Dust, Water,…)
  - Due to the Pre Arming System the Fuze is insensitive against soiling, Freezing,..
  - 2nd Safety Criteria according STANAG 4187
  - System modular for other Mortar Fuzes e.g. DM111

Detail Results DM93-S



- Wind Tunnel Test for validation of
  - Drag performance
  - Revolution forces
  - Design optimization
  - Release behaviour

Detail Results DM93-S

- Question: Is there an influence to the timework and the preset time with high rotating wind wheel?

  Response: no influence

- Question: Is there a possibility to change the preset time with increased pressure on the nose?

  Response: no influence

STANAG Compliance DM93-S

- STANAG 4187: compliant
- STANAG 2916: compliant with dimensions of electronically Time fuze
- MIL-STD 331B: 12 m drop and 1.5 m drop fulfilled
- Environment: all Tests fulfilled

Summary DM93-S as an example of combination of Reliability and Safety

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- Same handling i.a.w. preset Time
- New Safety aspect
- Safety requirement fulfilled up to launch increased safety
- No Safety Pin required

- Company Qualification fulfilled
- World wide no comparable solution available
- **In service fuzes can be further improved i.a.w. STANAG 4187**

Conclusion

- JUNGHANS Product shows a combination of
  - High Reliability (e.g. DM93 Fuze Family)
  - Second Safety Criteria (e.g. DM93-S)
- High Safety improves Handling and Flight Safety
- High Reliability provide Arming
- Reliable Arming and Firing results in decrease of ERW





JUNGHANS *Microtec* GmbH

Thank you for your kind attention!

Questions?

Development Of An Electronic Time Fuze For Self-Propelled Long Range Howitzer

SeongHun Kim

May 21, 2009

Contents

- Company Background
- Fuze Capability
- Fuze Needs
- Electronic Time` Fuze, HW101
- Fuze Setter
- Summary & Conclusion

Hanwha

Company Background

Hanwha Group

- Top 10 Largest Biz. Group in Korea

Hanwha Corporation

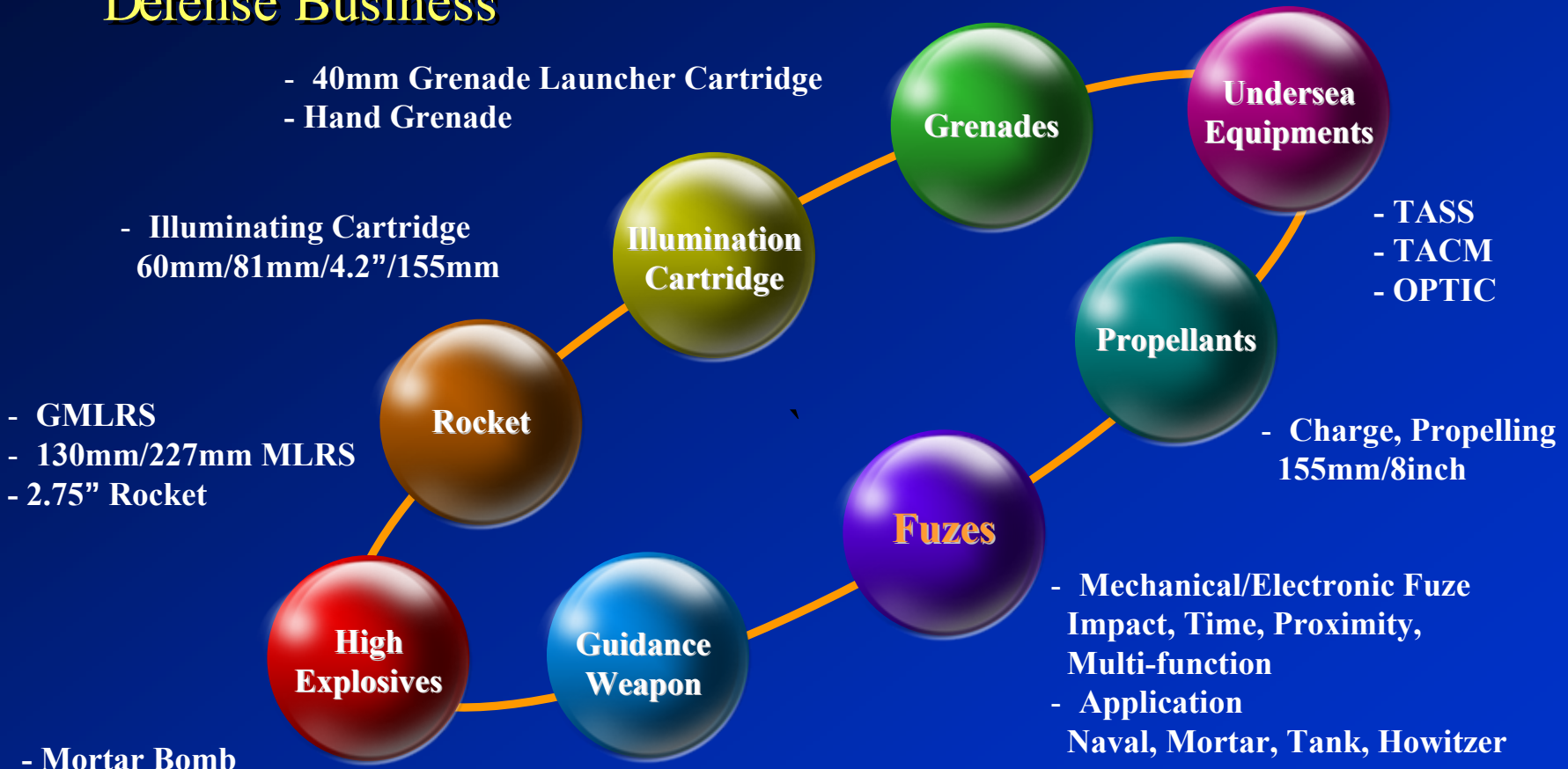
- Subsidiary of the Hanwha Group
- Founded in 1952, largest fuze company in Korea
- Sales : $570milion
- Employees : 2,800 persons



Hanwha

Company Background

Defense Business



Hanwha

Fuze Capability

Participating today in leading next generation fuzes
Development of electronic & mechanical fuze for :

Artillery Ammunition
- -105mm/155mm/203mm

Mortar Ammunition
- -60mm/80mm/120mm

Tank Ammunition
- -120mm

Medium Caliber Ammunition
- -20mm/25mm/35mm/40mm



Submunition
- -120mm
- -2.75”MPSM, MLRS

Rocket & Mine
- -MLRS
- -NSDA

Missile
- -Fuzes & ESAD



MEMS Safe & Arming Device

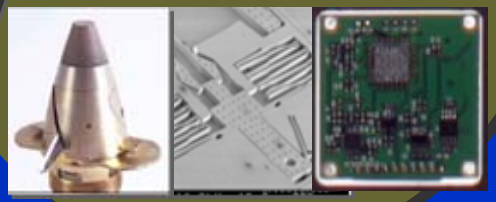
TCF

GPS Fuze

Smart Fuze

G-hardened ESAD

Non-lethal Weapon Fuze



Hanwha

Fuze Needs

Korean army needs an electronic time fuze for artillery and for high fire rate of self-propelled howitzer


K9


K55

K9 Self-Propelled Howitzer

155mm-52caliber, 40km Range
Automatic Fire Control System
Automatic Shell Loading System
Ammunition K310 DPICM BB etc
Fuze KM577A1 MTSQ etc
Propellant Modular Charge etc


KH179

Hanwha

Electronic Time Fuze, HW101

- Development by Hanwha investment for Korean army needs and global export
- Use in all types of 105 to 203mm HE, cargo, illuminating and smoke projectiles
- Time set either manually or by using an inductive fuze setter over a range from 0.5 to 199.9seconds
- The HW101 fuze is suitable for the latest generation of enhanced range munitions

Hanwha

Electronic Time Fuze, HW101



HW101



HW101A1

Operation	Mode	Function
	PD ET	PD ET/PD
	Accuracy	±0.1s
	Set	Inductive & manually
	* Set range : 0.5~199.9s (0.1s increment)	
Ballistic Environment	1,300~30,000G 2,500~30,000RPM	
Oper. Temp.	-43°C ~ +63°C	
Safety	400caliber	
Standards	Mil-Std-1316, Mil-Std-331	

Hanwha

Electronic Time Fuze, HW101

Dual setting system & high accuracy design
for user's requirements

- **Dual setting system**
  - **Uncabled setting by inductive means**
  - **Manual setting by three setting rings**
  - **Unlimited setting storage time**
    (no use of battery for setting)

- **Electronics**
  - **High G ruggedized by crystal based devices**
  - **Hybrid IC for small size**
  - **Time algorithms for high accuracy**

Hanwha

Electronic Time Fuze, HW101

G-hardend modular design of subass'y for common use artillery fuze

- **Power Supply**
  - **Reserve battery for long storage**
- **Safety & Arming Device**
  - **Two independent environment locks**
  - **Electronic arming not arm until 0.45s**
- **Explosive train**
  - **Out-of-line explosive train prior to 400caliber**
  - **27g RDX Booster (for HE)**

Hanwha

Electronic Time Fuze, HW101

High G test by gas gun system

- **High G demonstration of parts and assemblies**



Electronic function test by special instrument

- **Electronic function demonstration of assemblies**



Hanwha

Electronic Time Fuze, HW101

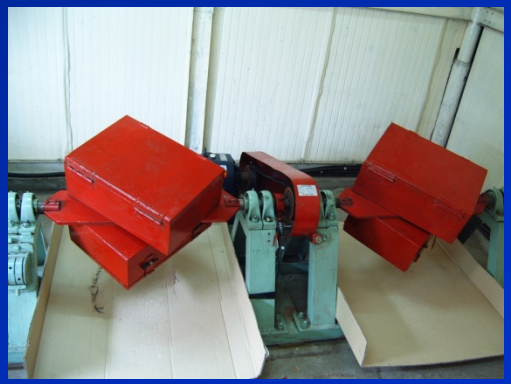
Environmental test : MIL-STD-331

- Vibration
- Temperature & Humidity(28days)
- Salt Fog
- Waterproofness
- Thermal
- Jolt / Jumble / 1.5m Drop / 12m Drop









Hanwha

Electronic Time Fuze, HW101

Field test : Full charge validation



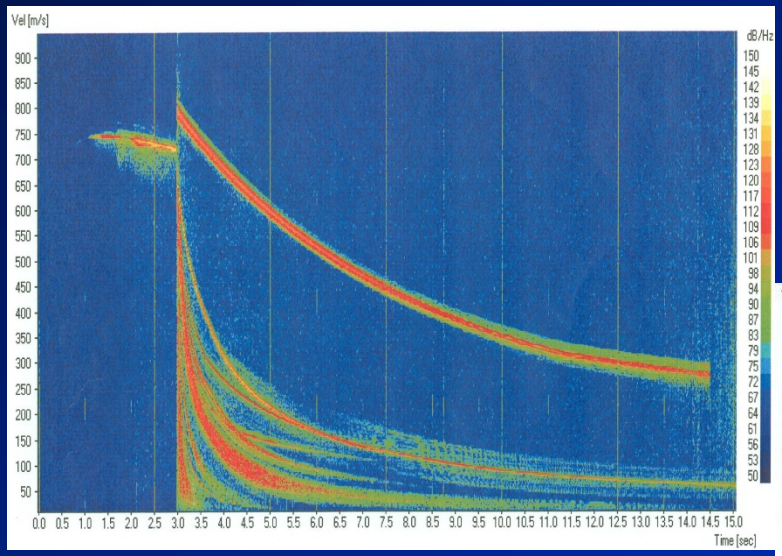


Caliber	Weapon	Projectile	Charge/Zone	Setting(s)	Accuracy(s)
155mm	K9 Howitzer(52cal)	K310	K676 MCS	35	Requirement : <±0.1 Recorded : <±X.XX
	M198 Class(52cal)	K310	K676 MCS	109	
	KH179(39cal)	KM549A1	KM203/8S	97	
105mm	KM101A1	KM1	KM67/7	48	
203mm	KM115	KM106	KM2/5	20	

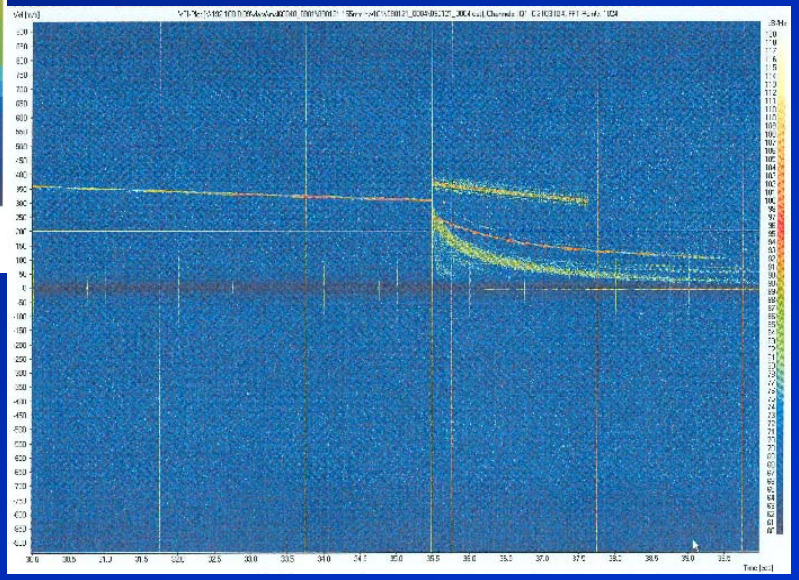
Hanwha

Electronic Time Fuze, HW101

Field test : Submunition expelling validation



K9 -K310 DPICM-MCS



Fuze Setter

Developed for hand held use and vehicle mounted use



Interface with user via
LED & keypad
Low power consumption
>3,000setting operations

Operation	Mode	Function
	Display	Seven seg. LED
	Setting	16 keypads
	Monitoring	Set time
		Power capacity
Oper. Temp.	-43°C ~ +63°C	
Power	Lithium Battery Auxiliary External Power	
Standards	Mil-Std-810F, Mil-Std-461E	

Hanwha

Fuze Setter

Setter can be integrated with automatic shell loading system and fire control system.

Setting operation

Interface with user via LED & keypad

Have two mode : Set Mode, Read Mode

Display **Time set** **PD set** **Power**



Hanwha

Fuze Setter

EMC test : MIL-STD-461F



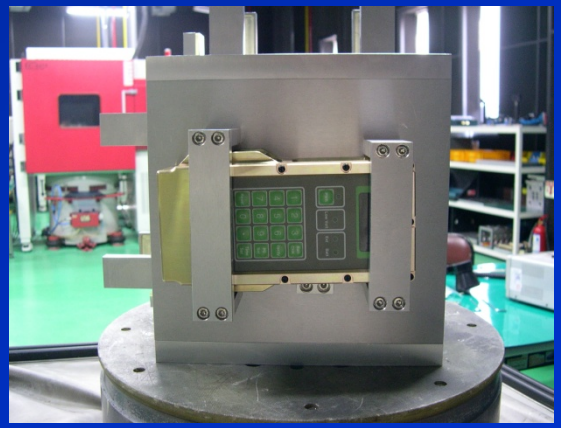


Environmental test : MIL-STD-810E

- Thermal
- Leakage
- Transport

  Vibration





Summary & Conclusion

- Wide operational flexibility
  - HW101 and HW101A1 fuzes
  - Inductive mean setting
  - Fuze setter operation
    .Hand hold or vehicle mounted
    .Integrated with auto shell loading system and fire control systems
- Improved performance with high time accuracy
- Low cost achievement by modular design
- Proved reliability by real fire test

Hanwha

JUNGHANS microtec





Dual Function Fuze DM173 for Cartridge 120mm x 570 HE

53rd Annual Fuze Conference 2009 (Orlando, FL)

Martin LEONHARDT

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Content

- Program Background, Application
- Requirements
- Fuze Functioning Modes
- Overview of the Cartridge and Fuze
- Arming Criteria's
- Technical Solutions
- Photos of Fuze Hardware
- Project Status
- Trial Results

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Program Background

- Germany, Switzerland and The Netherlands have agreed to co- operate on a joint program

- Rheinmetall W&M and JUNGHANS Microtec have teamed up to develop a multi- purpose projectile for use against
  - Hard / soft targets
  - Anti- personnel
  - Vehicles
  - Buildings, etc.

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Application

– 120mm smoothbore Tank Gun



Combat Battle Tank “Leopard 2”

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Requirements

- STANAG 4157; STANAG 4187; STANAG 4235; STANAG 4239; STANAG 4439
- MIL-STD 331C; MIL-STD 1316; MIL-STD 810
- Muzzle Safety Distance ≥ 20m
- Arming Distance ≤ 80m
- Overall functional Reliability ≥ 98%
- Functioning Temperature -46°C to +63°C
- Storage Temperature -54°C to +71°C

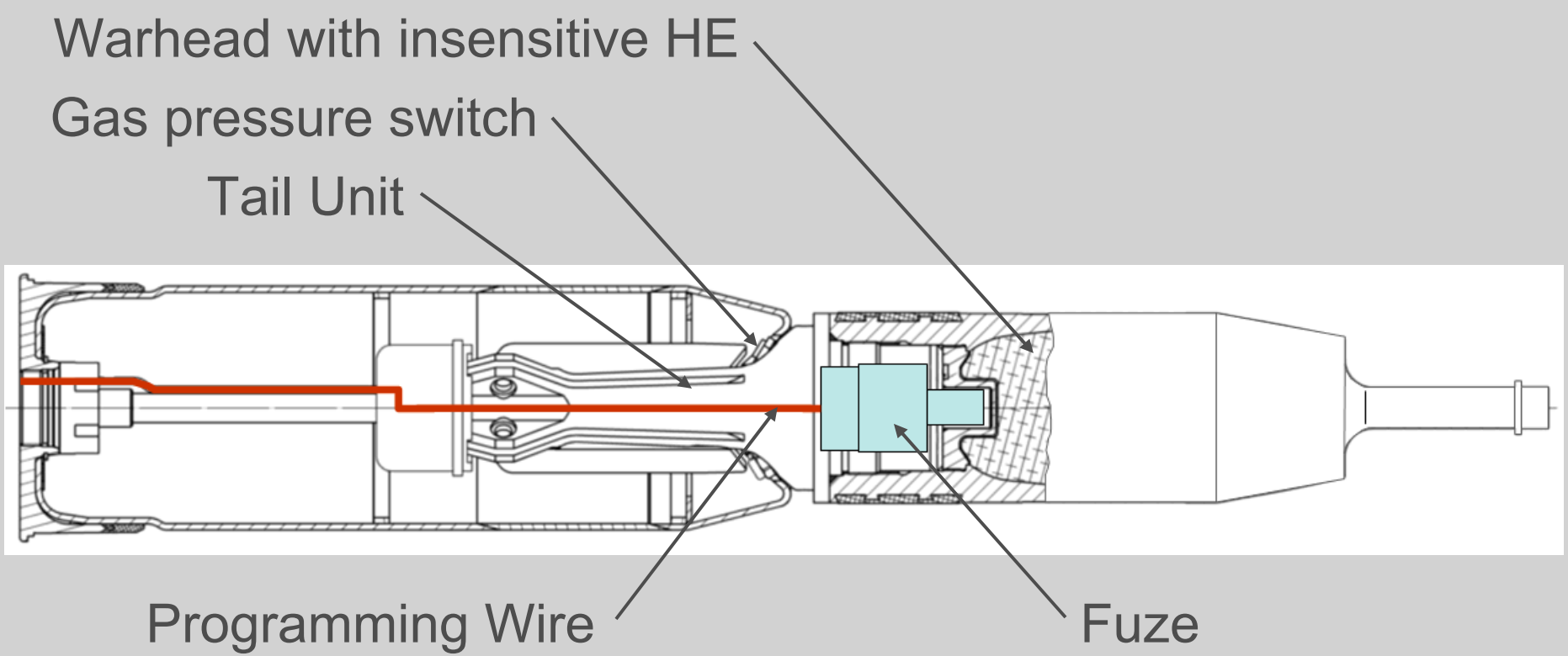
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Fuze Functioning Modes

- Programming
  - Impact mode with optional delay
  - Airburst, programmable ignition time from 64ms to 12s
  - Self- destruct function
- Default
  - Impact mode without delay
  - Self- destruct function

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Overview of the Cartridge DM11



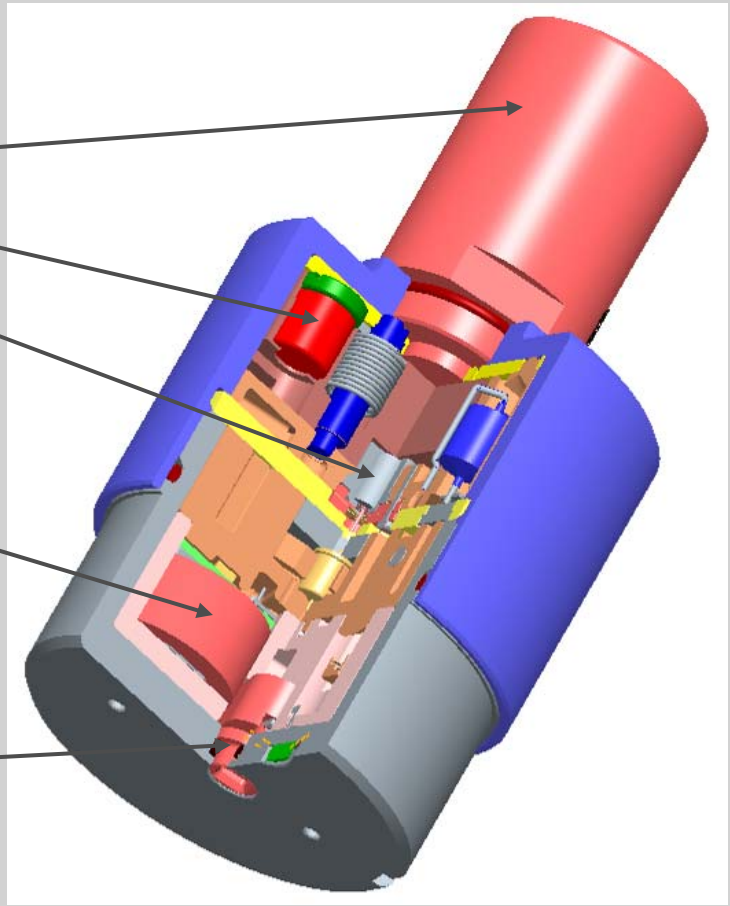
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Main Fuze Components

Firing Train
Insensitiv booster
Relay charge
Detonator

Set back generator

Electrical connector

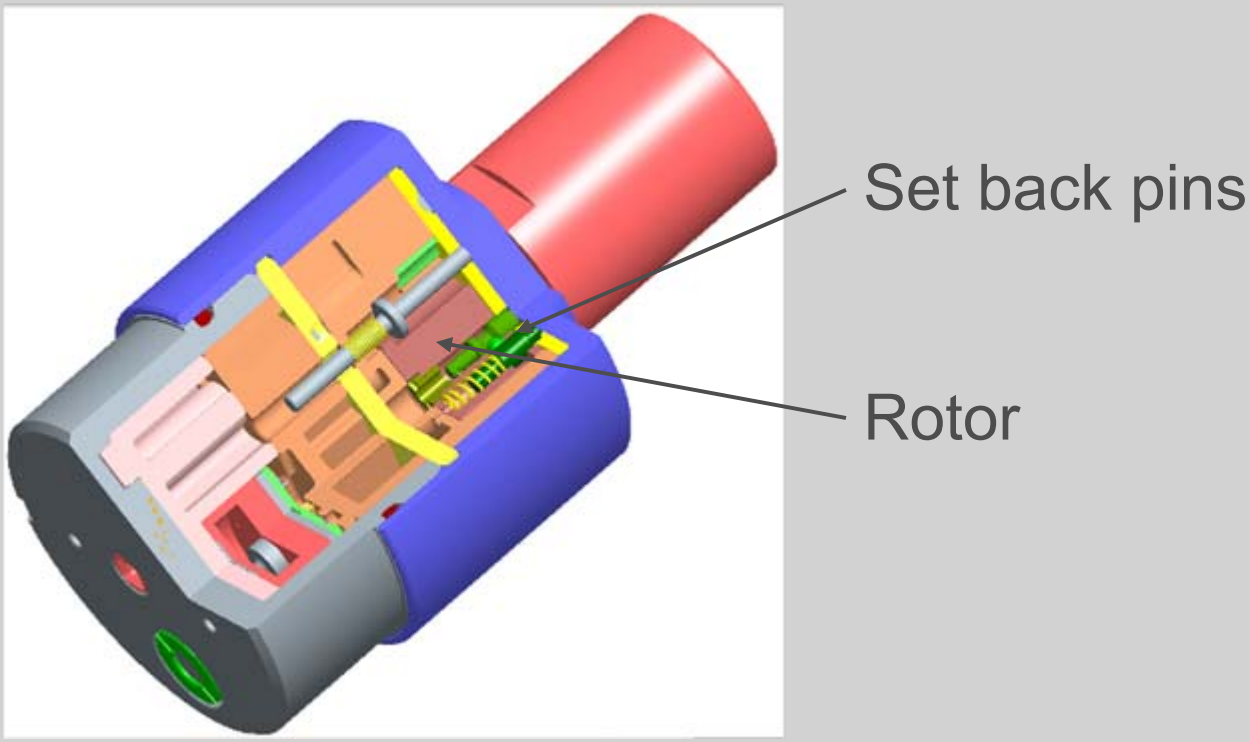


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Arming Criteria's

- 1st Safety
  - Safety Element: Set back pins
  - Arming Criteria: Acceleration

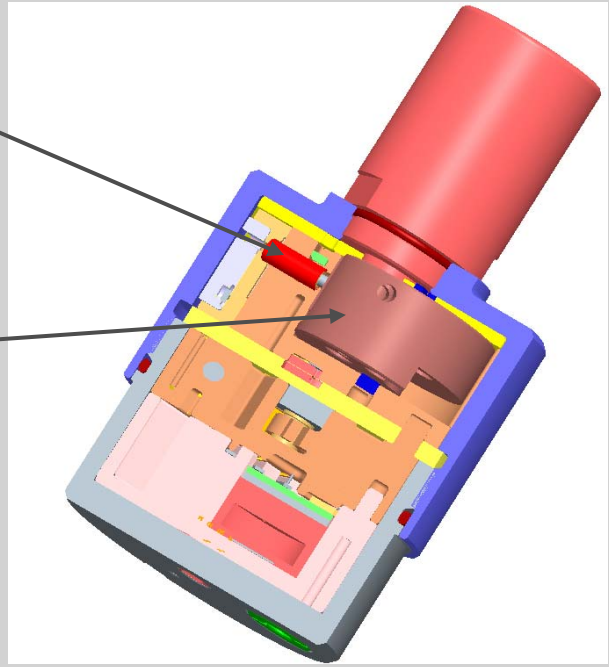


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Arming Criteria's

– 2nd Safety

- Safety Element: Piston actuator / gas pressure switch
- Arming Criteria: Gas pressure of the propellant



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Technical Solutions

- Safety Distance
  - Electronical timer starts after gas pressure switch is closed
  - Piston actuator will be fired when the time is elapsed
- Programming
  - Digital
  - Talk- back signal
  - Continuous update

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Technical Solutions

- Power Supply
  - Via the control unit for the µP
  - Basic fuze function via a set back generator

- Target Impact Detection
  - Shock wave sensor (Piezo)
  - Omni- directional switch

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Photo of Fuze Hardware



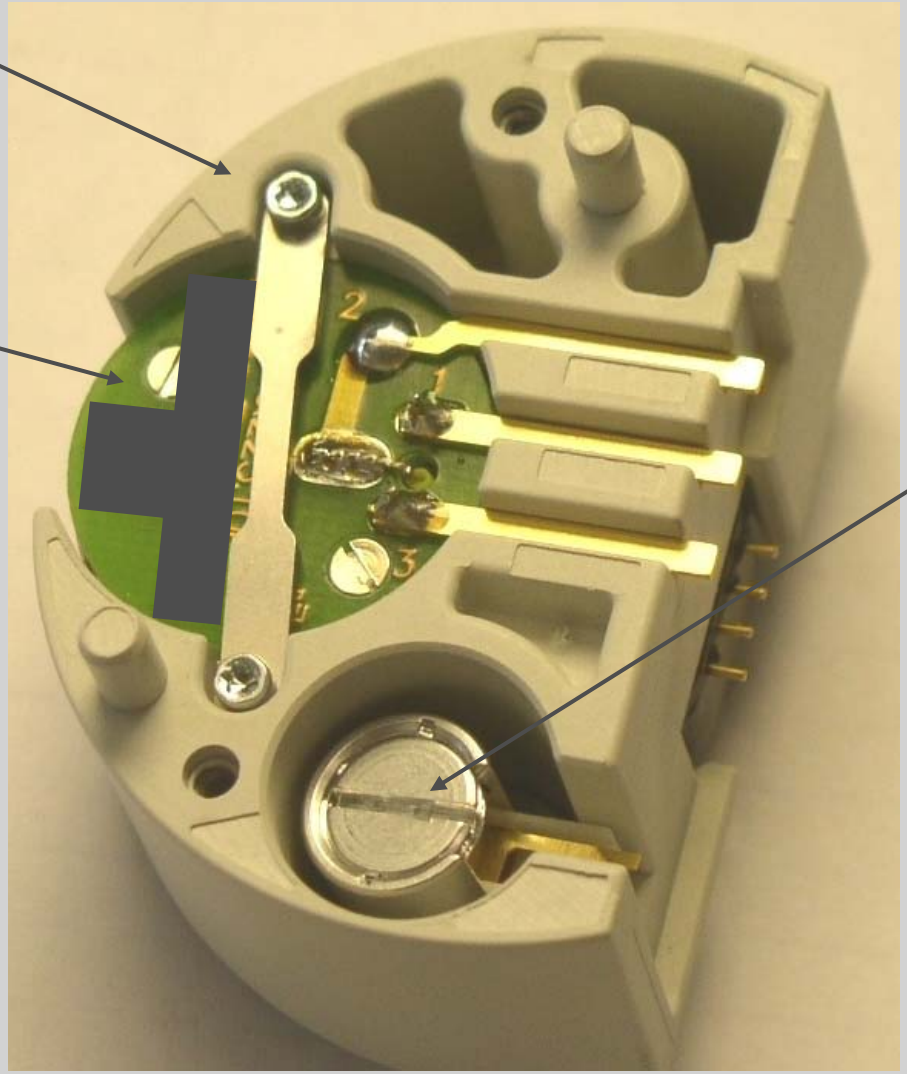
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Photo of Fuze Hardware

Plastic part of the SAD

Set back Generator



Piezo, pre-assembled

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Project Status

- Development phase finished end of 2008

- Fuze qualification successful finished end of March 2009
  - 142 functioning / safety trials without failures conducted
  - Safety- and ESD / EMV tests conducted

- System qualification will be finished end of 2009
  - Cartridge qualification
  - Safety release for manned firing
  - Release of the system into service

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Trial Results

– Firing against a 24cm brick wall, impact mode with time delay



Photo provided by

RHEINMETALL DEFENCE

Copyright **JUNGHANS M***icrotec* GmbH

Trial Results

- Firing against a 8’’ double reinforced concrete wall, PD mode



Photo provided by

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Trial Results

- Firing against an earth and timber bunker, PD mode



Video provided by

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Trial Results

– Firing against a 10mm steel plate, PD mode



Video provided by

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Trial Results

- Firing against dismounted infantry, squad in wedge formation, AB mode



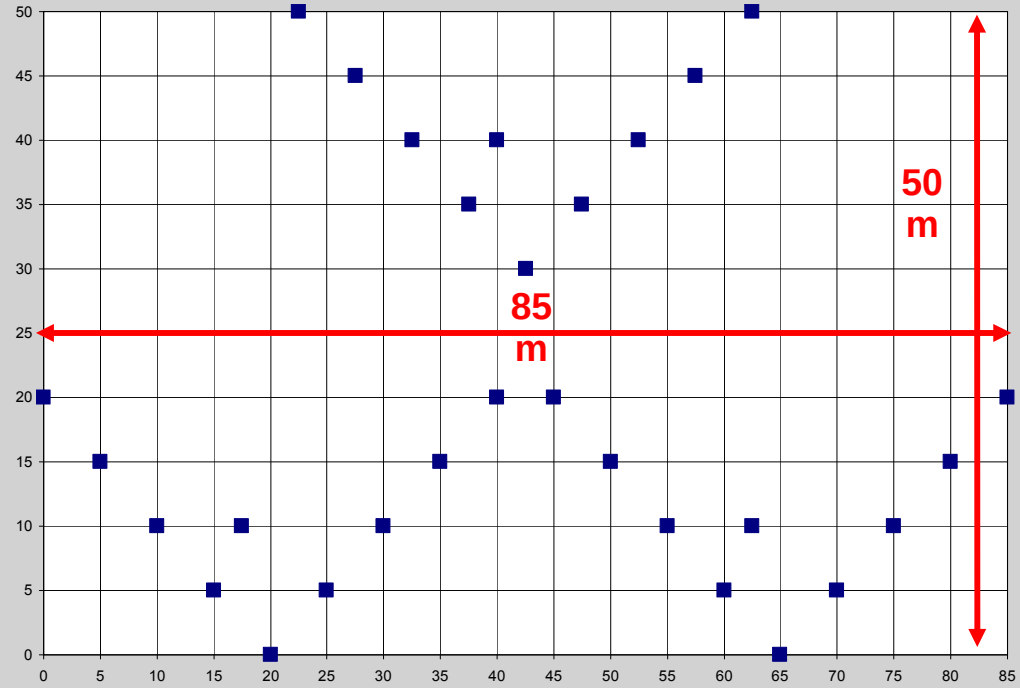
Video provided by

RHEINMETALL DEFENCE

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Trial Results

- Firing against dismounted infantry, squad in wedge formation, AB mode









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Trial Results

– AB firing (see also following slow motion)



Video provided by

RHEINMETALL DEFENCE

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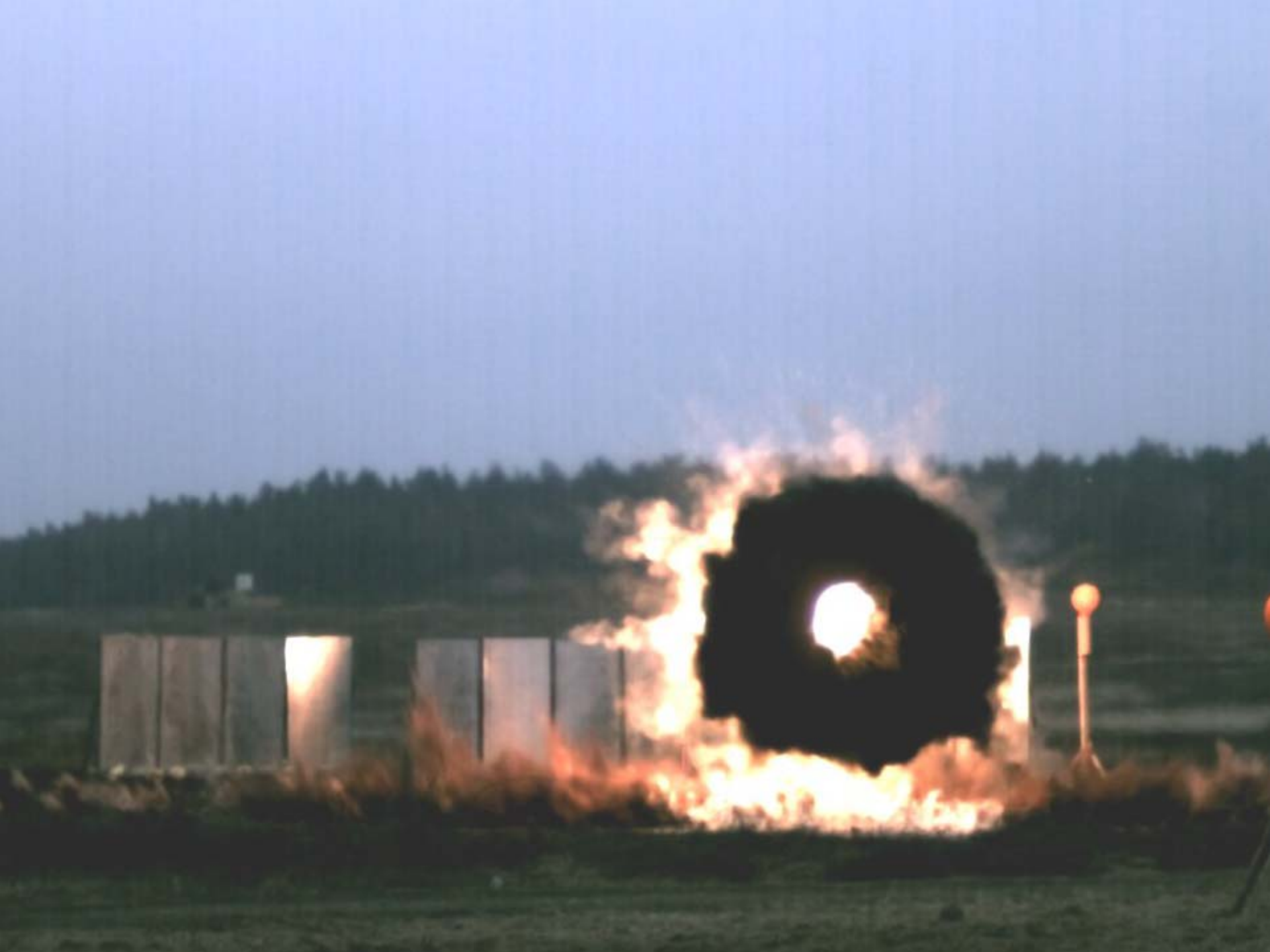


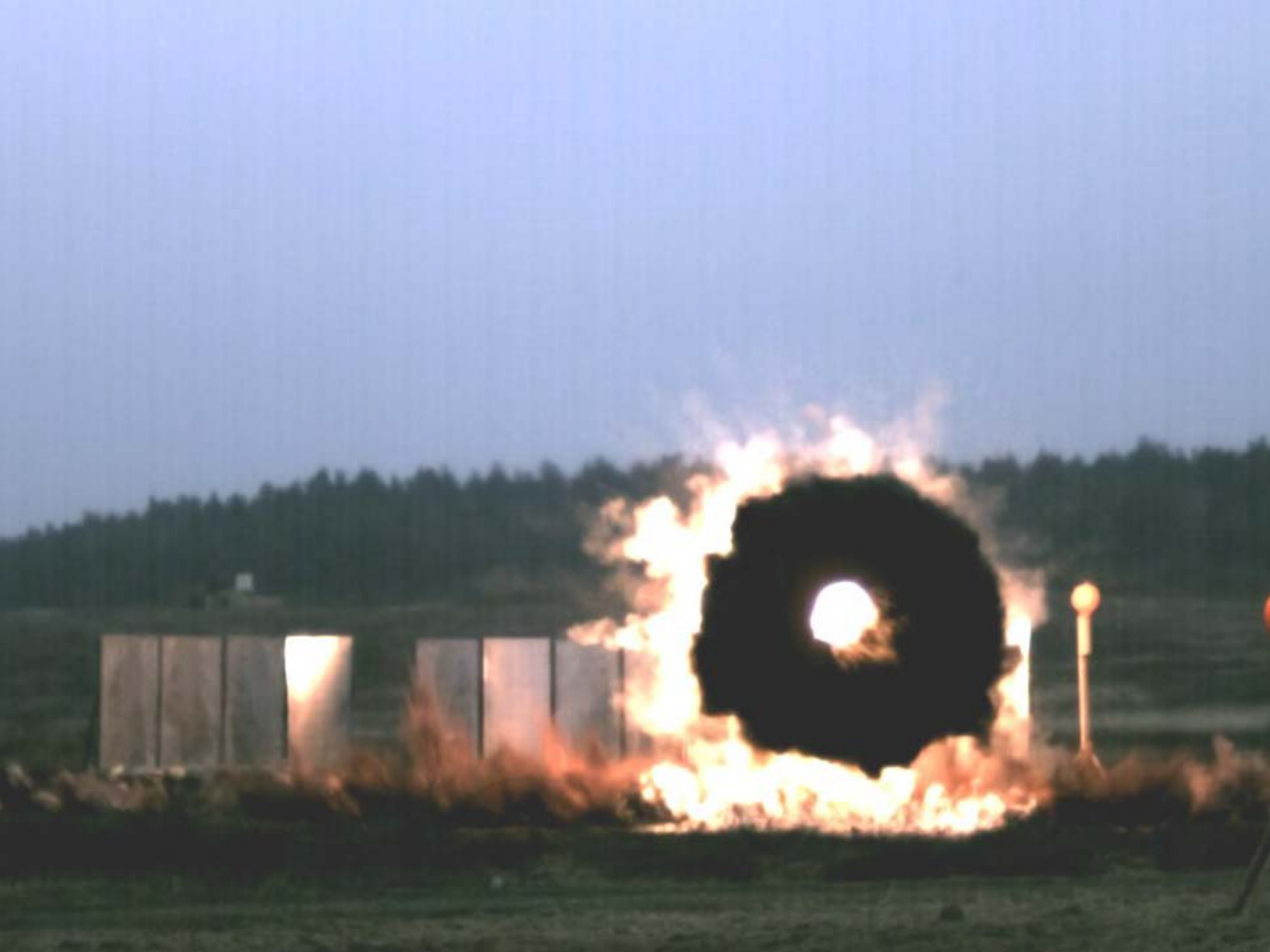


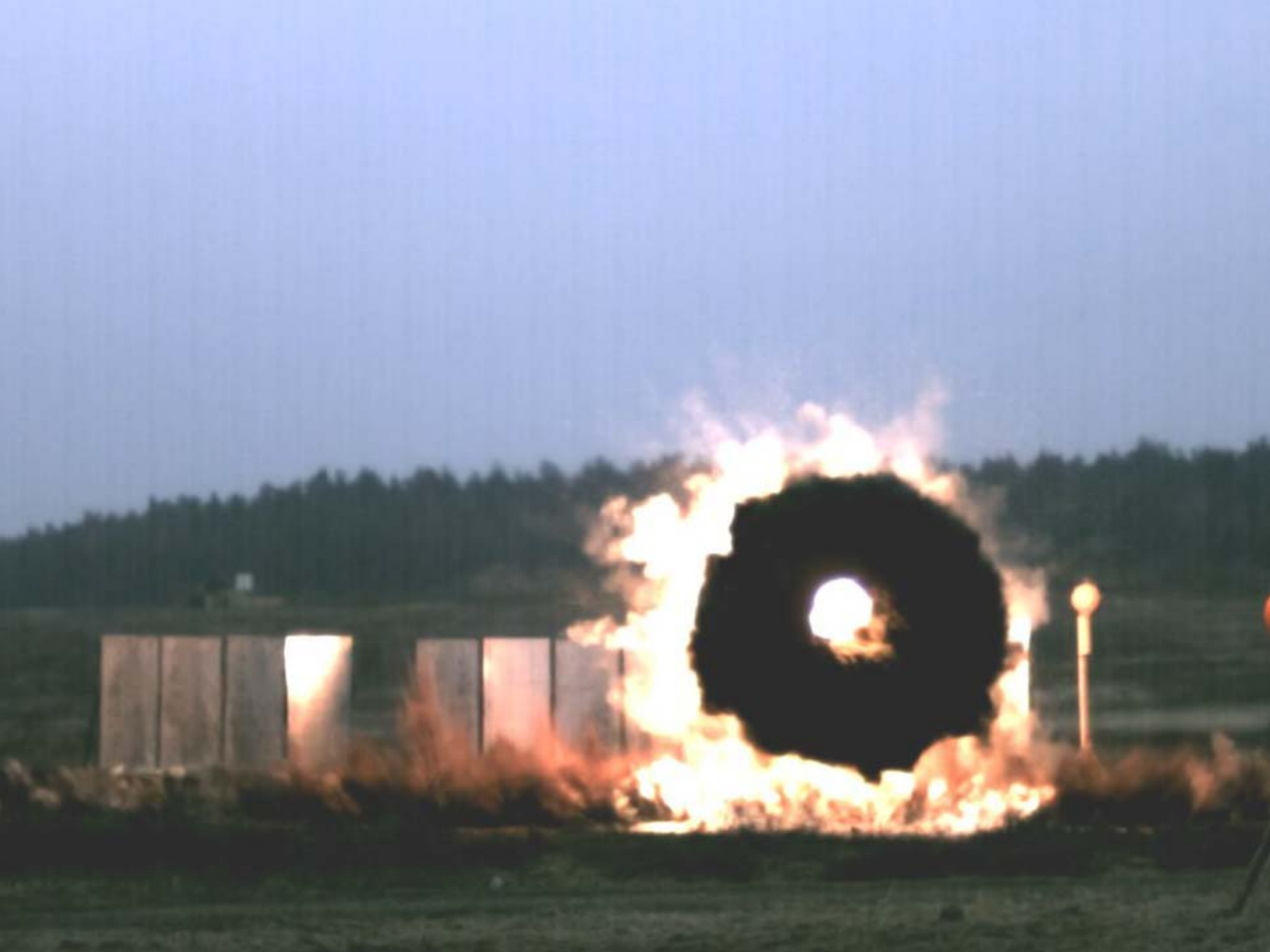


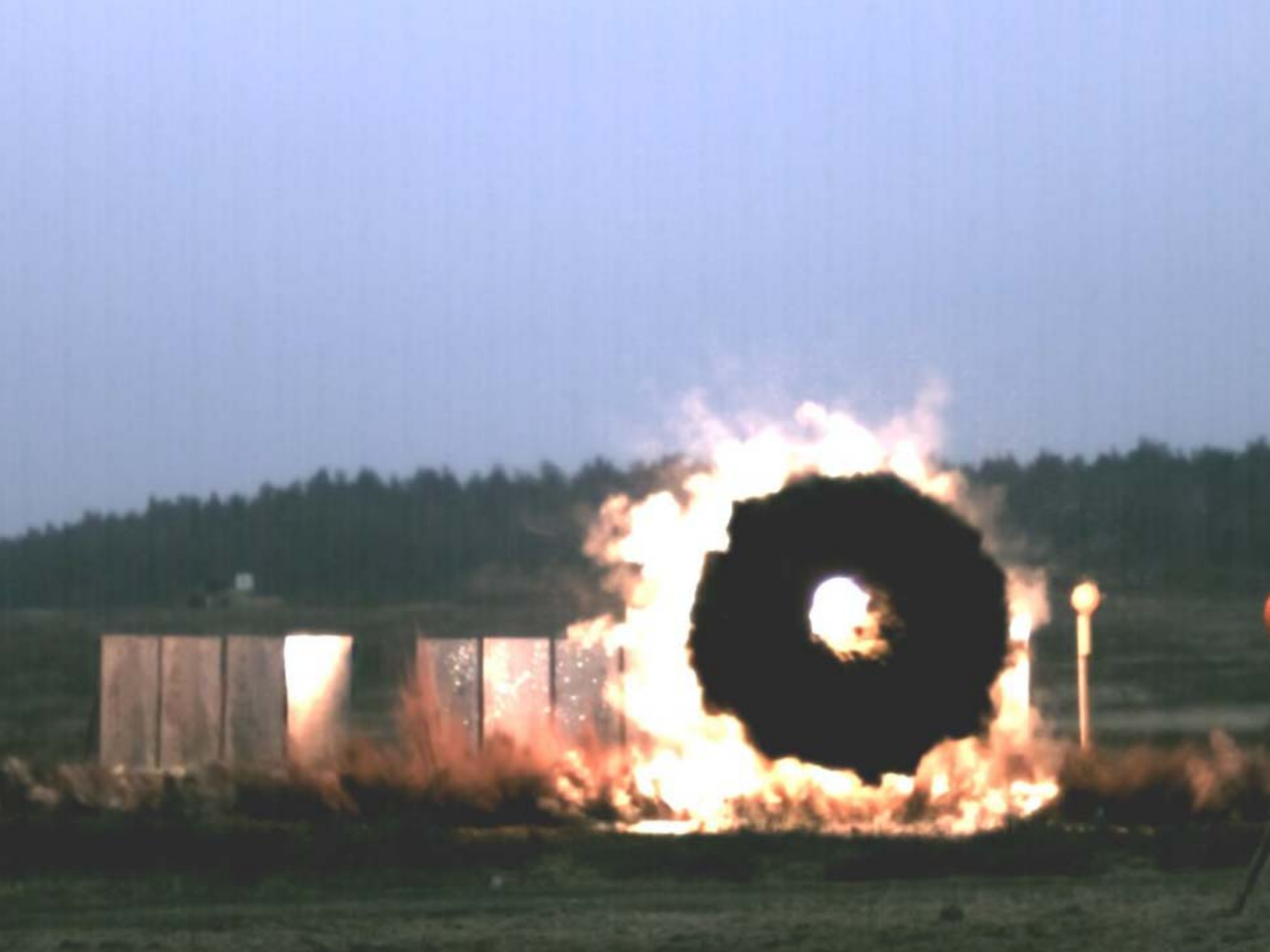


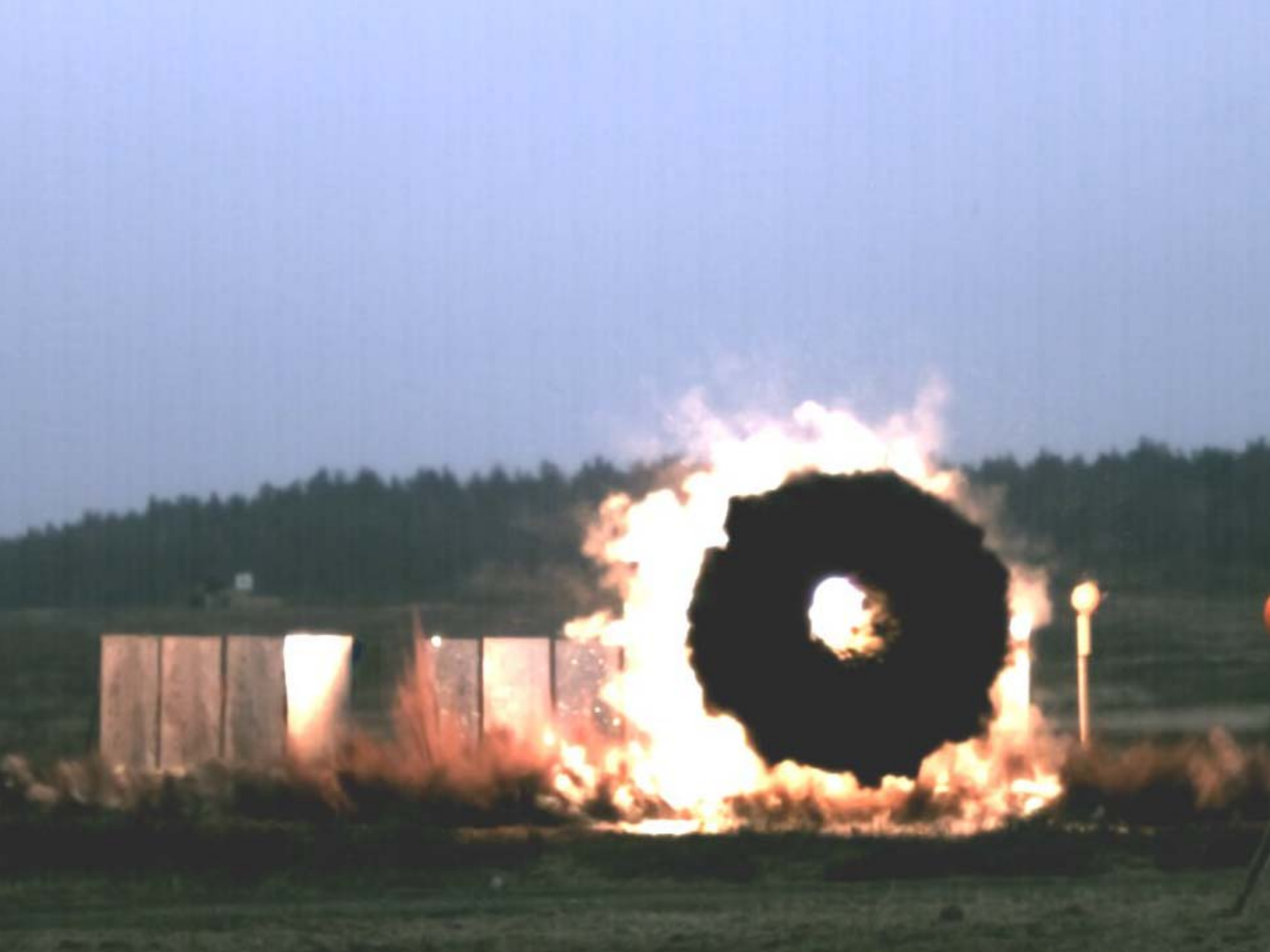


























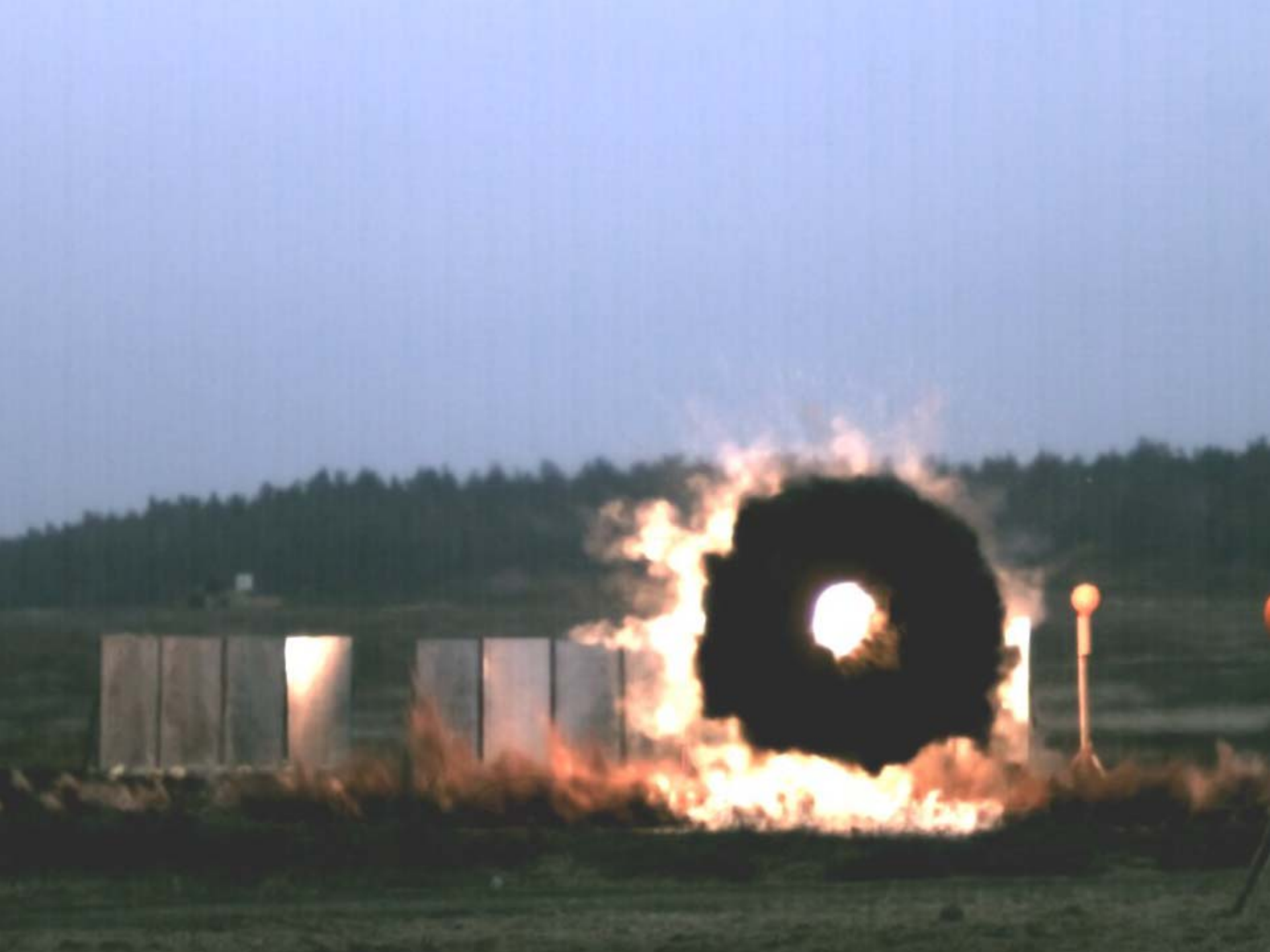


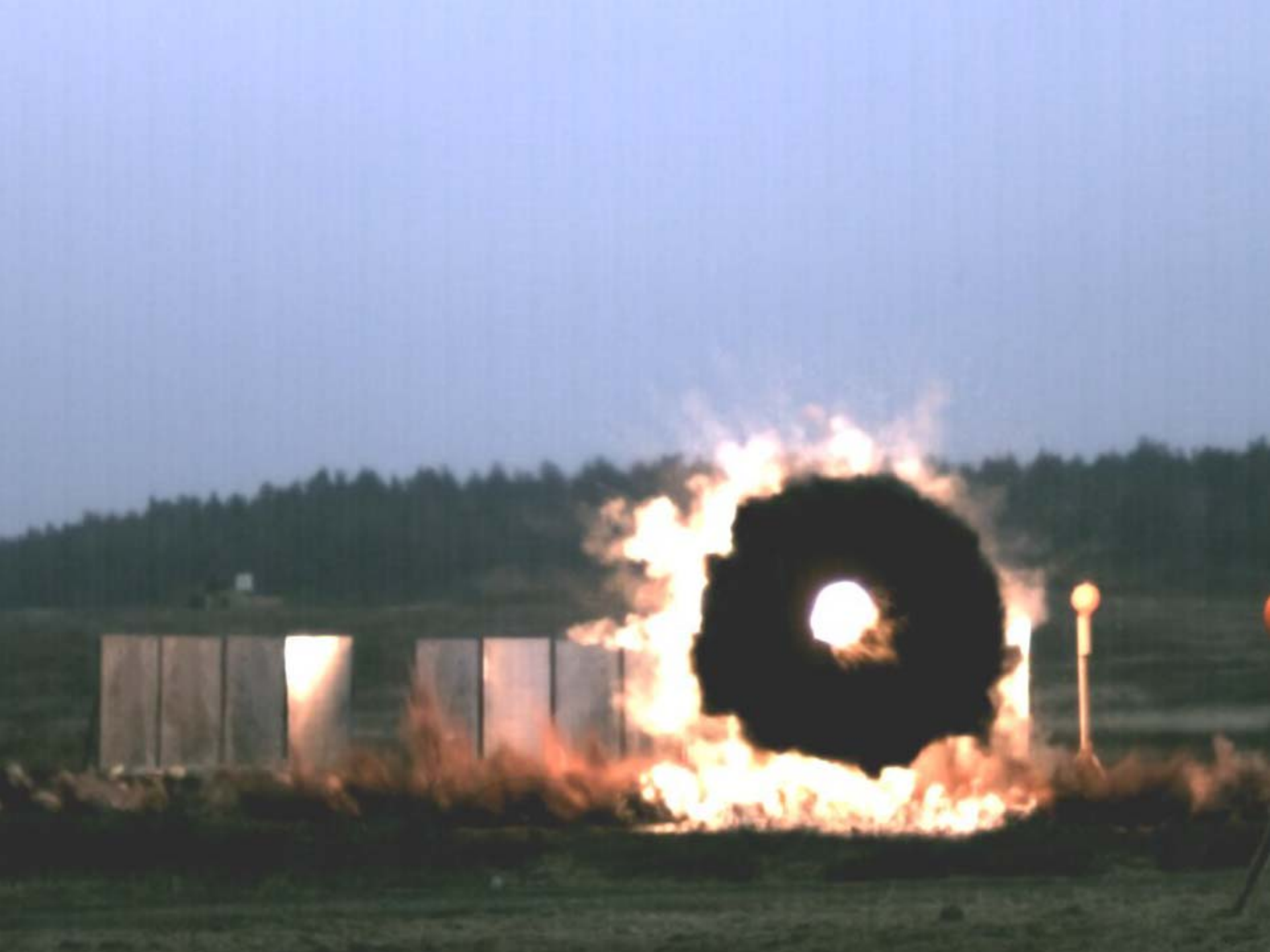


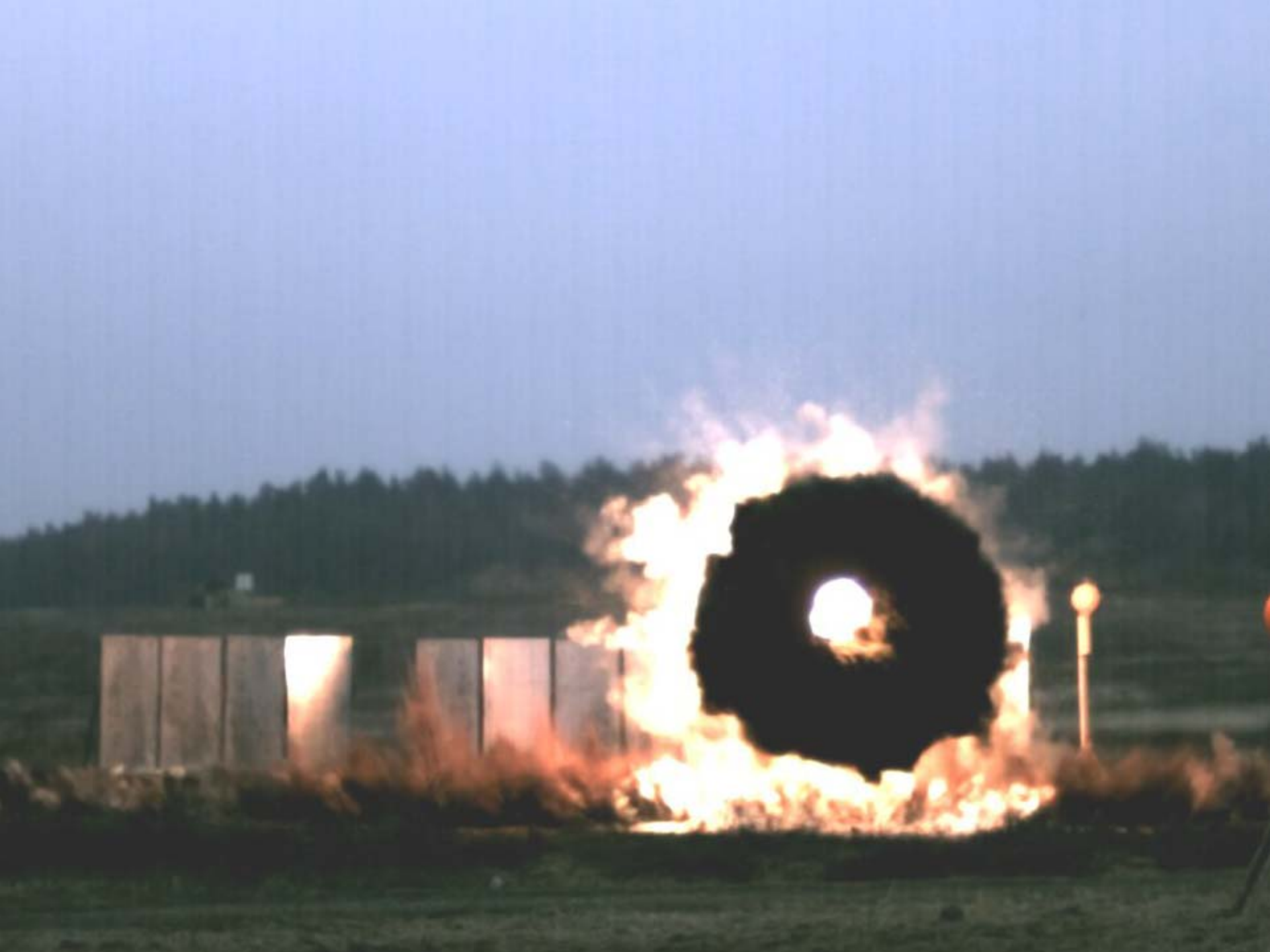


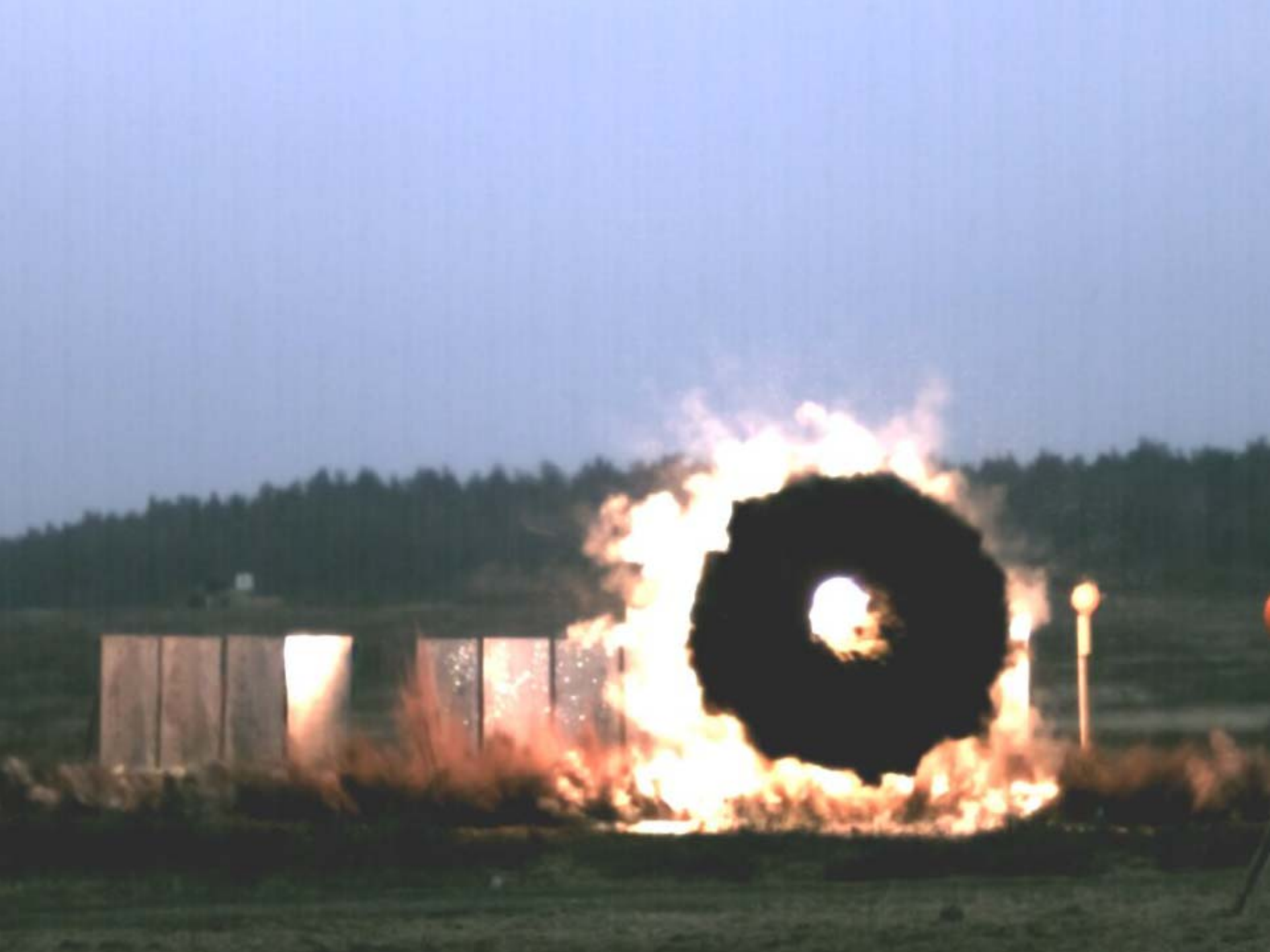


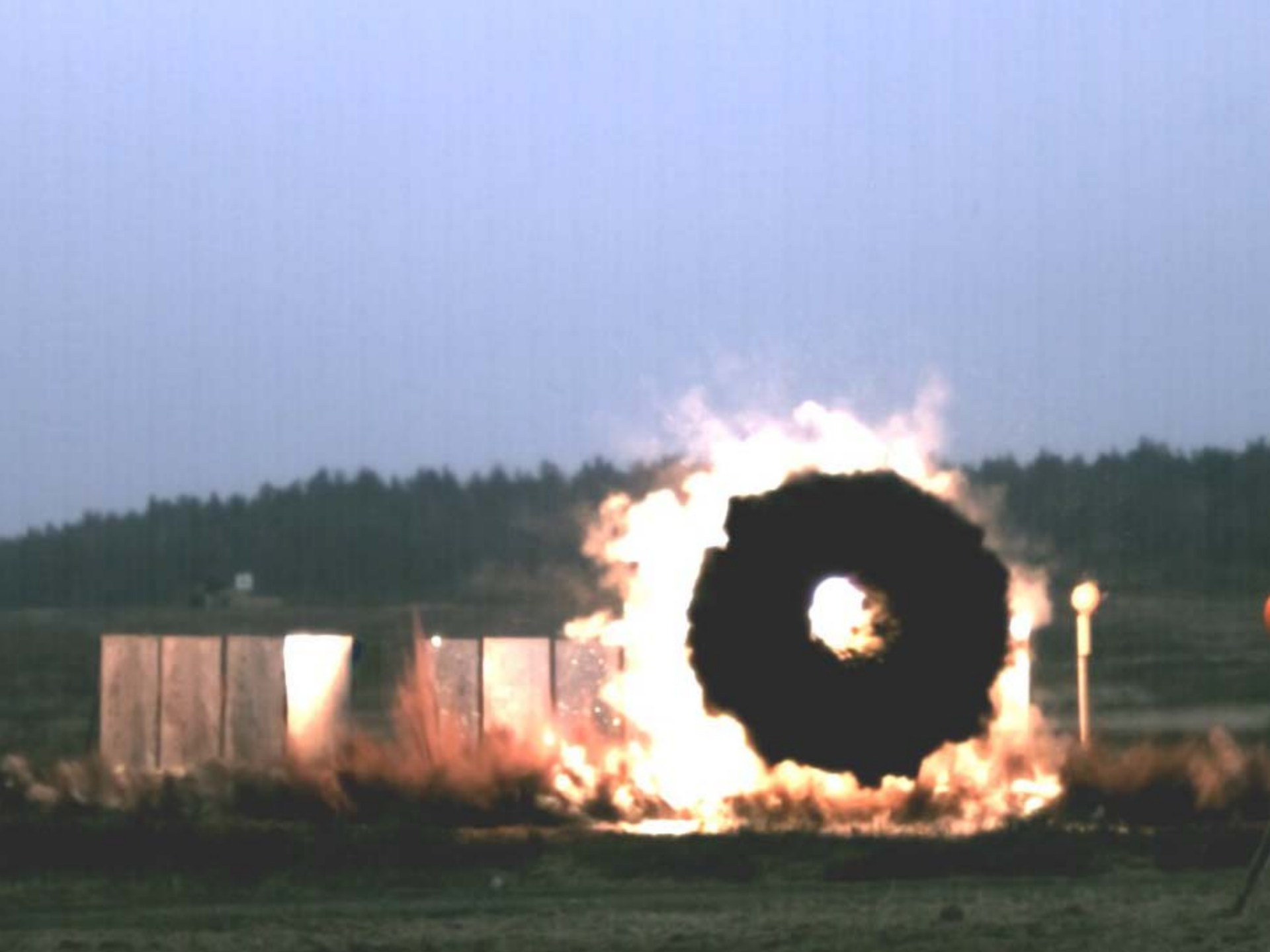


















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Trial Results

– Summary of all



RHEINMETALL DEFENCE

EZU

Erprobungszentrum Unterlüß

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Thank you for your kind attention!

Any questions ?

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Point of Contact

JUNGHANS Microtec GmbH
Unterbergenweg 10
D- 78655 Dunningen - Seedorf

Martin LEONHARDT (Product Management)

Phone: +49 7402 181 175
Fax: +49 7402 181 132
Email: martin.leonhardt@junghans-microtec.de

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A new generation of high-shock accelerometers with extreme survivability performance

Tom Kwa, George Pender, James Letterneau, Keith Easler

National Defense Industries Assn 53rd Fuze Conference
May 21, 2009

Presentation by Randy Martin

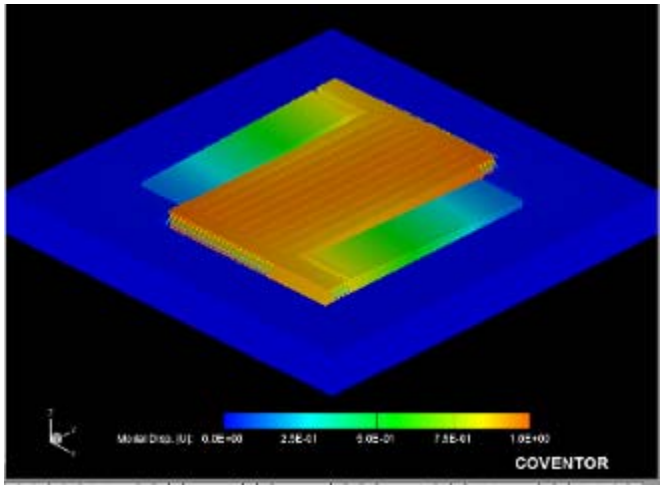
Endevco Corporation
30700 Rancho Viejo Road
San Juan Capistrano, CA 92675

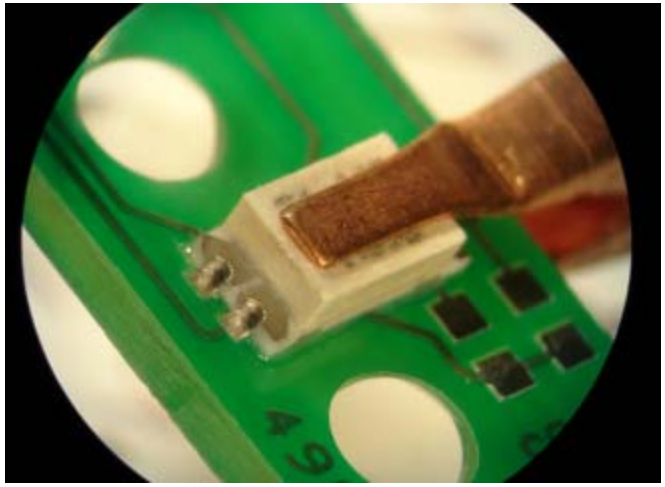
Distribution Statement: Approved for Public Release

MEGGiTT

Next generation high-shock accelerometer fuze application requirements

- Survivability and Reliability
- Small footprint
- Surface mountable
- Low power consumption
- Short warm-up time
- High resonance frequency
- High input resistance
- Light damping





MEGGiTT

Performance parameter design targets

Range = 20 kg	Next generation	Previous Generation
Survivability	6 times range	3 times range
Size (footprint)	25 mm^2	100 mm^2
SMT	Yes	No
Power	4 mW (5 V)	150 mW (10 V)
Warm-up drift	10 g	50 g
Resonant freq	100 kHz	350 kHz
Input resistance	6500 Ω	650 Ω
Gas Damping	Yes	No
Over-range stops	Yes	No

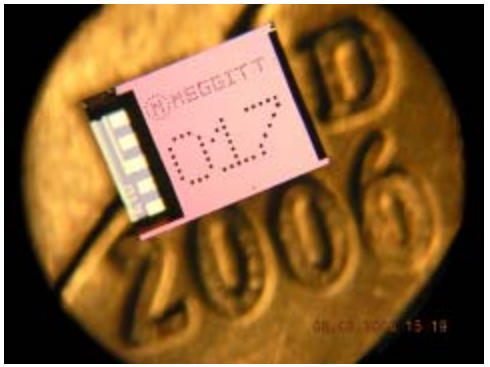
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Survivability enhancements

- Mechanical stops prevent damage to die from high-g over-range inputs
  - Base and lid serve as stops (z-axis) – walls for x, y
  - Approximately 3 times full-scale range (> for x, y)
- Light damping attenuates resonance (Q-killer) to prevent damage due to ‘ringing’
  - Mechanism is squeeze-film gas damping
  - 0.05 nominal (can be adjusted) – gap, core mod
  - Additional benefit is preventing saturation of signal conditioning circuitry
  - Mechanical equivalent of electrical filter

MEMS die design enhancements

- 'Teed' gauge process
  - Developed for Auto Crash test market
  - Provides robust mechanism for a production environment MEMs-based Piezoresistive strain concentrators (US Patent Nos. 6,988,412 and 7,146,865)
- Higher resistance, lower power
- Improved warm-up characteristics
- Single-sided wire bonding on tri-stack
- Deep Reactive Ion Etch (DRIE)
- MEMS die manufactured by Endevco at our SV facility

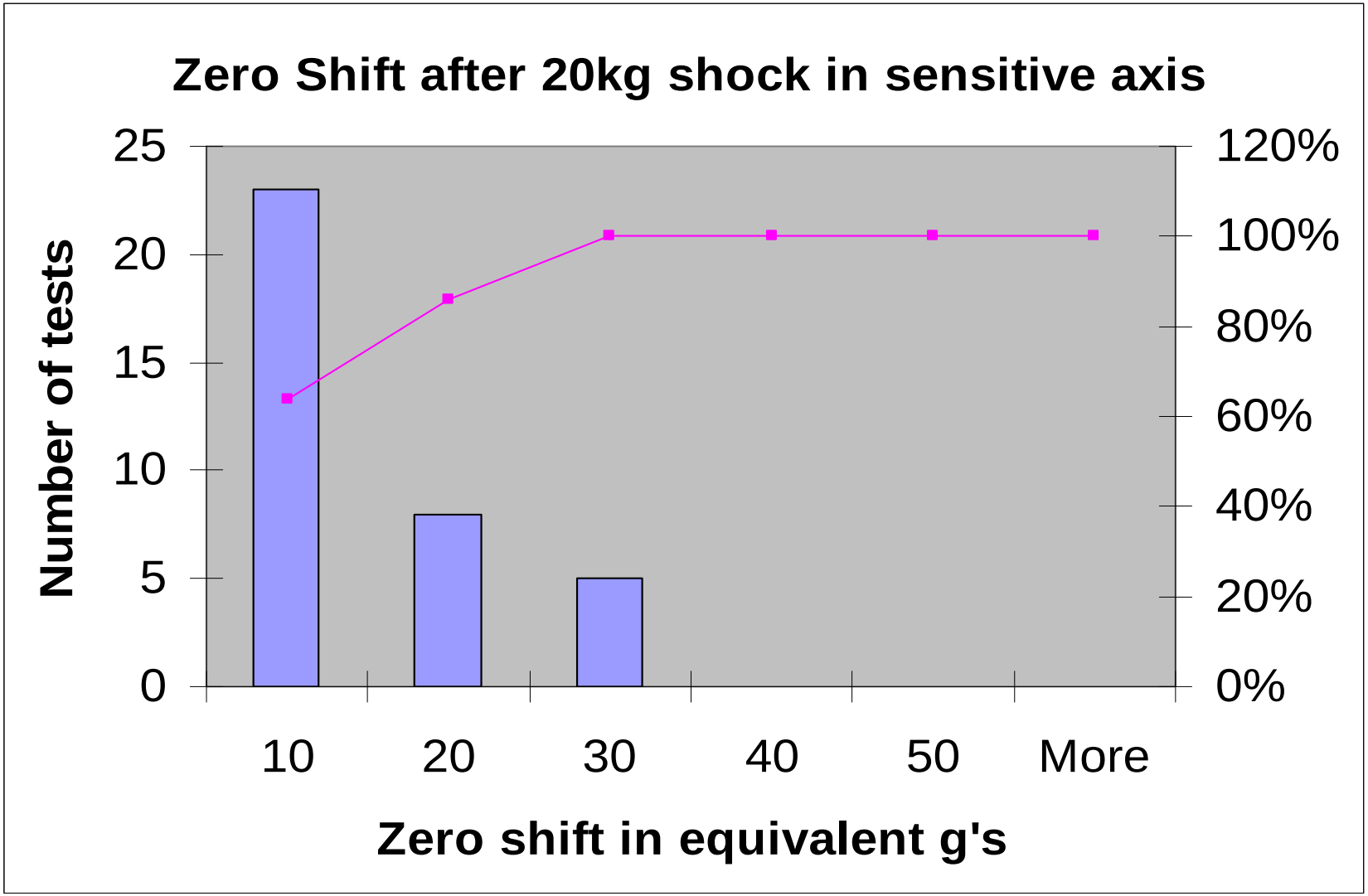


Endevco MEMS, Sunnyvale, CA



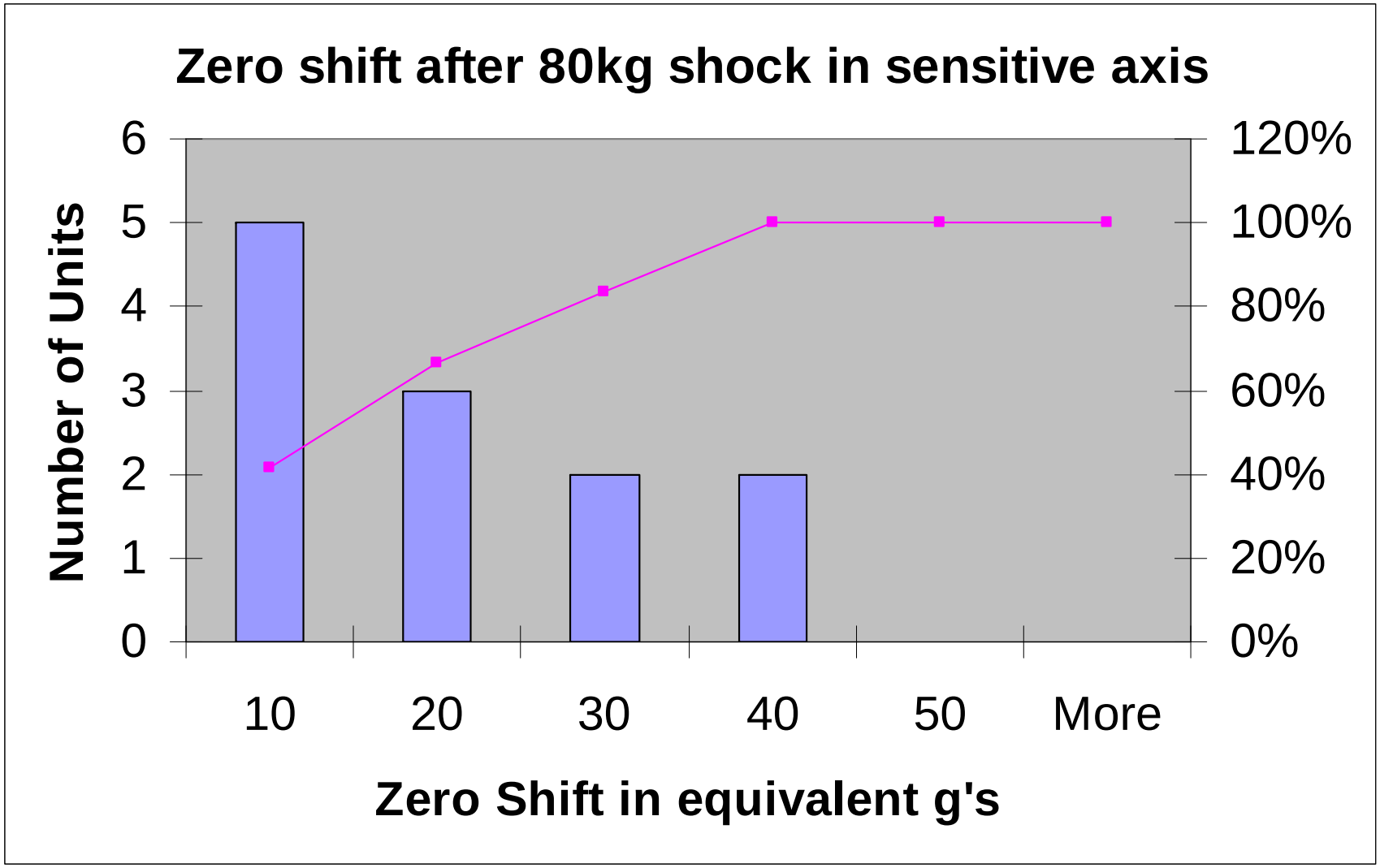
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Zero Shift Over Shock Data (1 of 3)



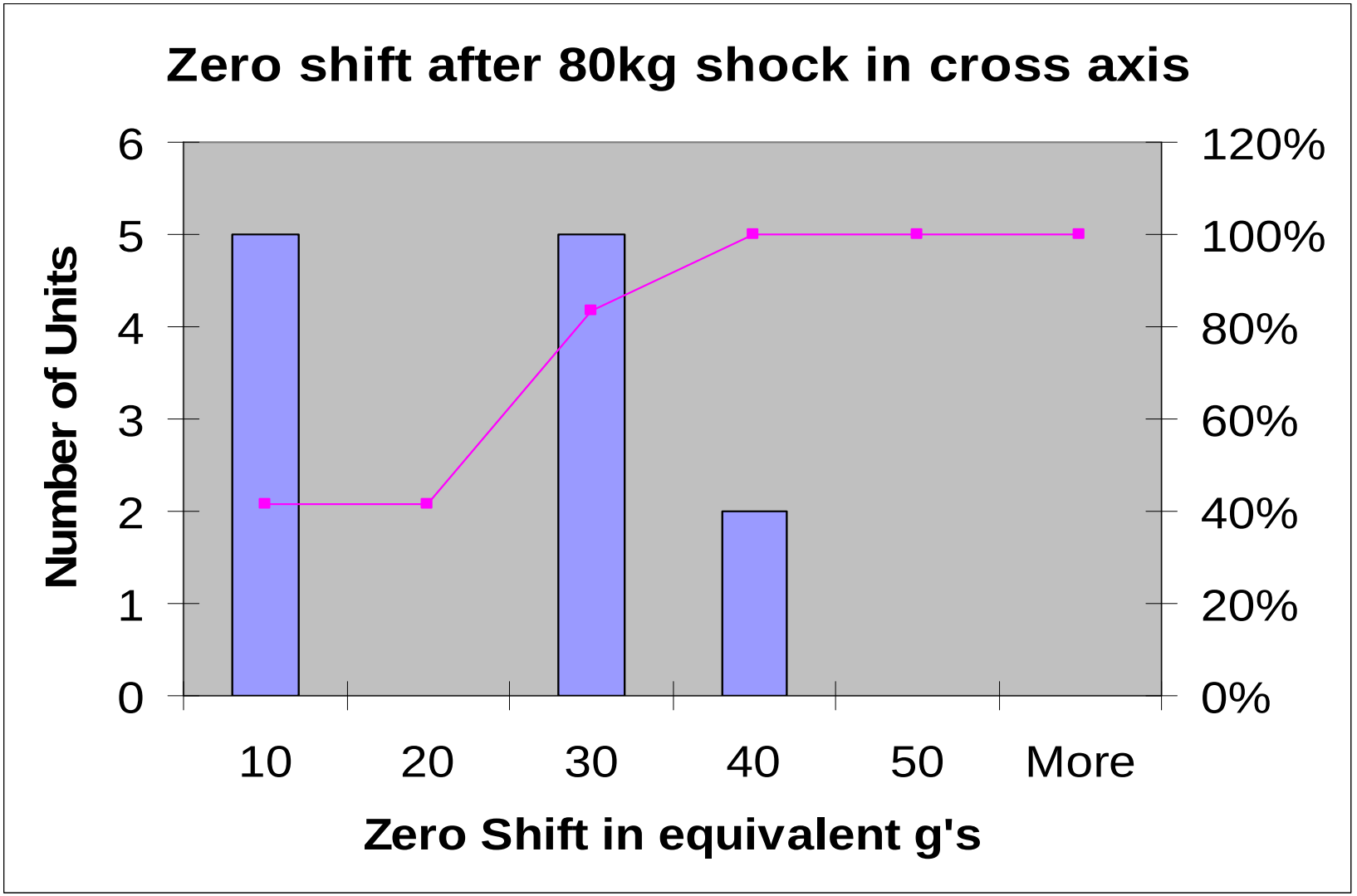
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Zero Shift Over Shock Data (2 of 3)



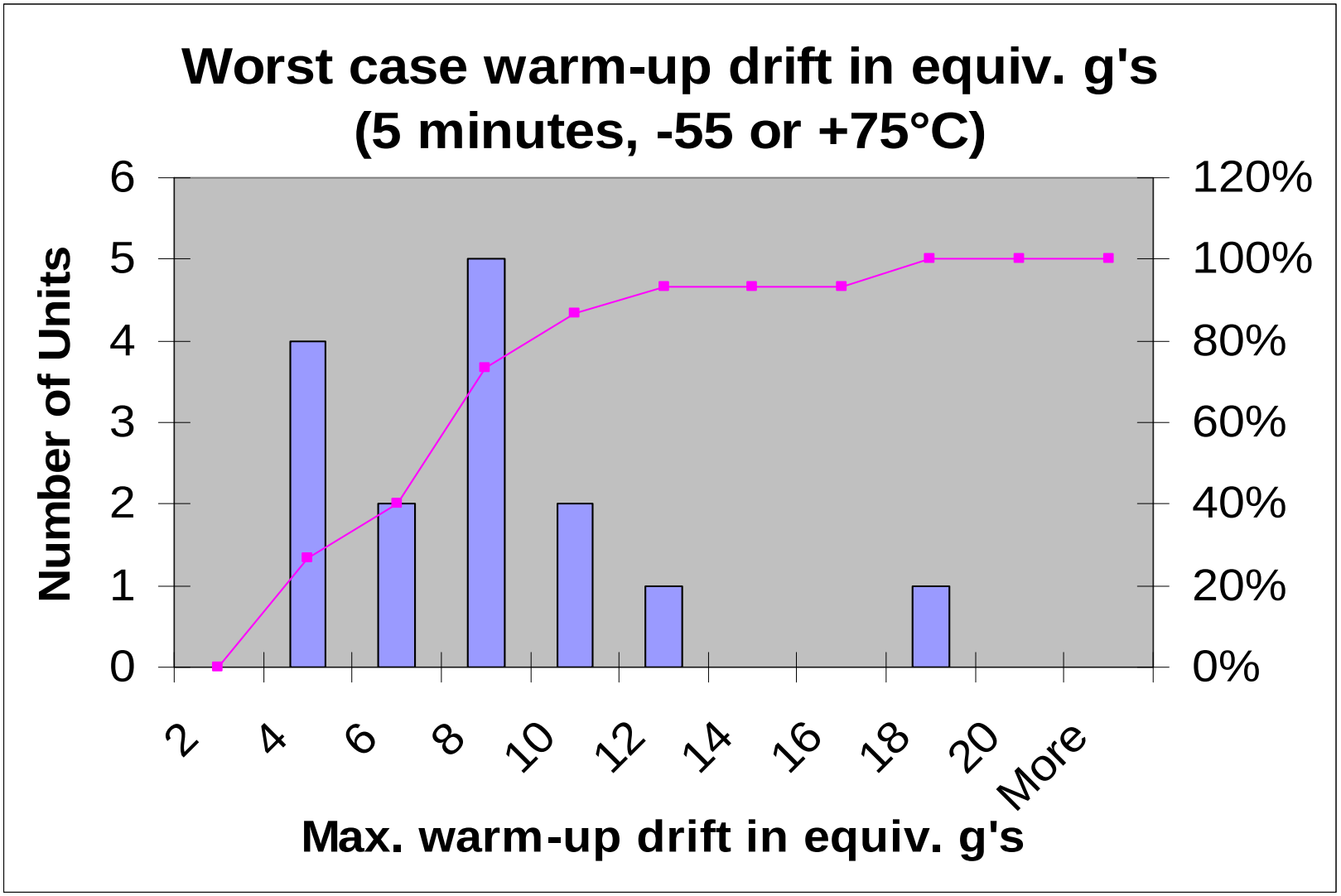
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Zero Shift Over Shock Data (3 of 3)



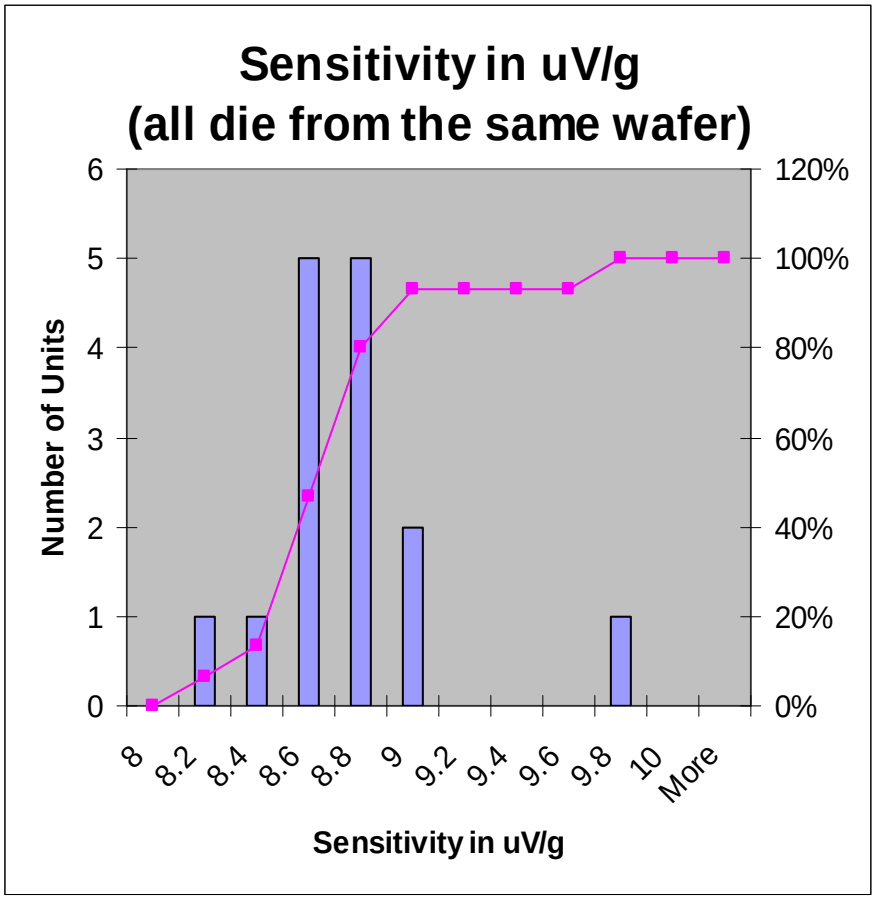
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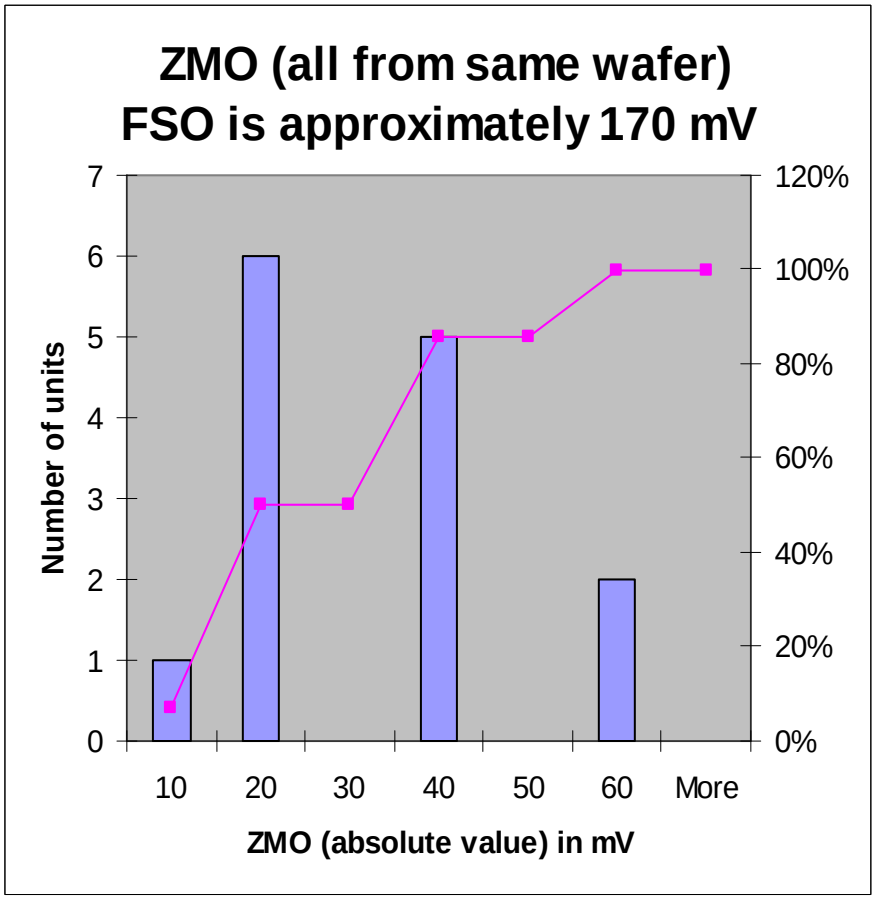
Warm-up Drift Data



MEGGiTT

Sensitivity and ZMO Test Data

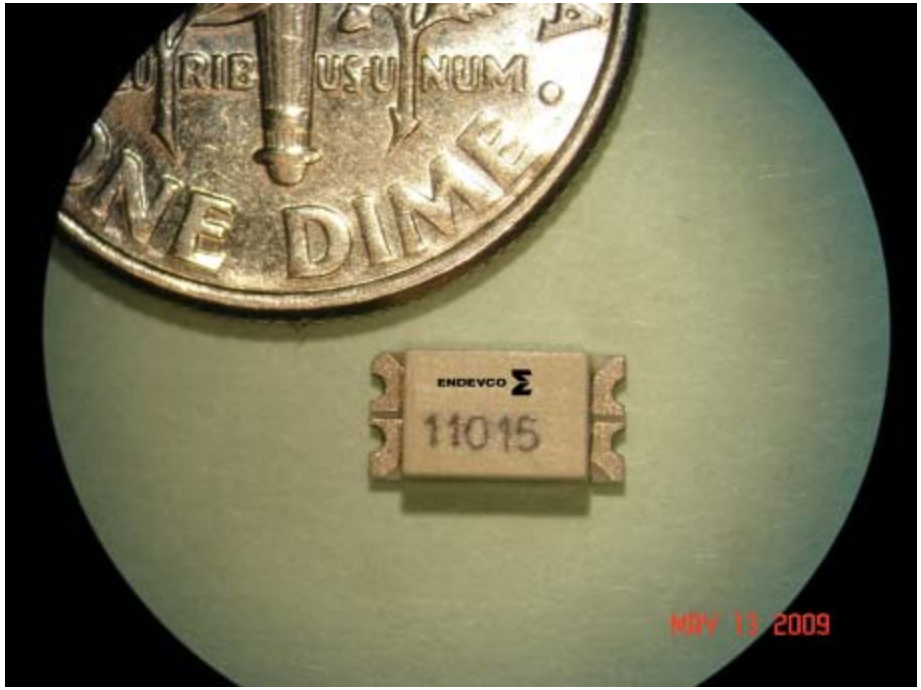




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Test Data Summary for 20 kg accelerometer

- Sensitivity: 8.5 μV/g nominal (at 5 V excitation)
- ZMO: < ±100 mV (most units ±50 mV)
- Input resistance: 6.5 kΩ (±0.5 kΩ)
- Worst case warm-up drift: < 10 g's
  - 5 minutes, constant temperature: -55 C, +25 C, +75 C
- Noise:
  - < 5 μVrms (broadband);
  - 3 g-pk (settings below)
  - (AC coupled, 3 Hz-10 kHz BPF, 200 ksps, 200 ms window)
- Shift in ZMO over shock
  - 20 kg sensitive axis < 30 g
  - 80 kg sensitive axis < 40 g
  - 80 kg cross axis < 40 g



MEGGiTT

Fuzing & Ordnance Systems

L-3 FOS
3975 McMann Road
Cincinnati, Ohio 45245-2395

Development of a Hard Target Void Sensing Fuze for High Mechanical Shock Load Applications
May 21, 2009

Presented By

Perry Salyers, Manager IR&D

"This presentation consists of L-3 Corporation general capabilities information that does not contain controlled technical data as defined within the International Traffic in Arms (ITAR) Part 120.10 or Export Administration Regulations (EAR) Part 734.7-11."

Agenda

- Intelligent Penetrating Fuze CRADA
- Program Overview
- Design Overview
- 1st Howitzer Test Series Results
- Design Updates
- 2nd Howitzer Test Series Results
- Team Members
- Summary

Intelligent Penetrating Fuze CRADA

- CRADA between Air Force Research Laboratory Munitions Directorate and L-3 FOS
- The CRADA was adopted to:
  - Exchange information & advance current technology for next generation intelligent fuzing for hard target penetrators

Program Overview

- Review past lessons learned
- Develop system concepts
- Review & iterate design concepts
- Develop detailed design
- Build prototype hardware and perform environmental tests
- Perform 1st series howitzer tests
- Evaluate test results & update design
- Perform 2nd series howitzer tests
- Evaluate test results & prepare final report

The information in this presentation is of general capabilities and open for public release

Design Overview

- Multiple concepts and trade studies reviewed
- Modular approach selected
- Cantilevered fuze structure selected
- Design developed for structure and impact survivable modules
  - Arm & Fire Module
  - Intelligent (data recorder) Module



Initial Design

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Design Overview

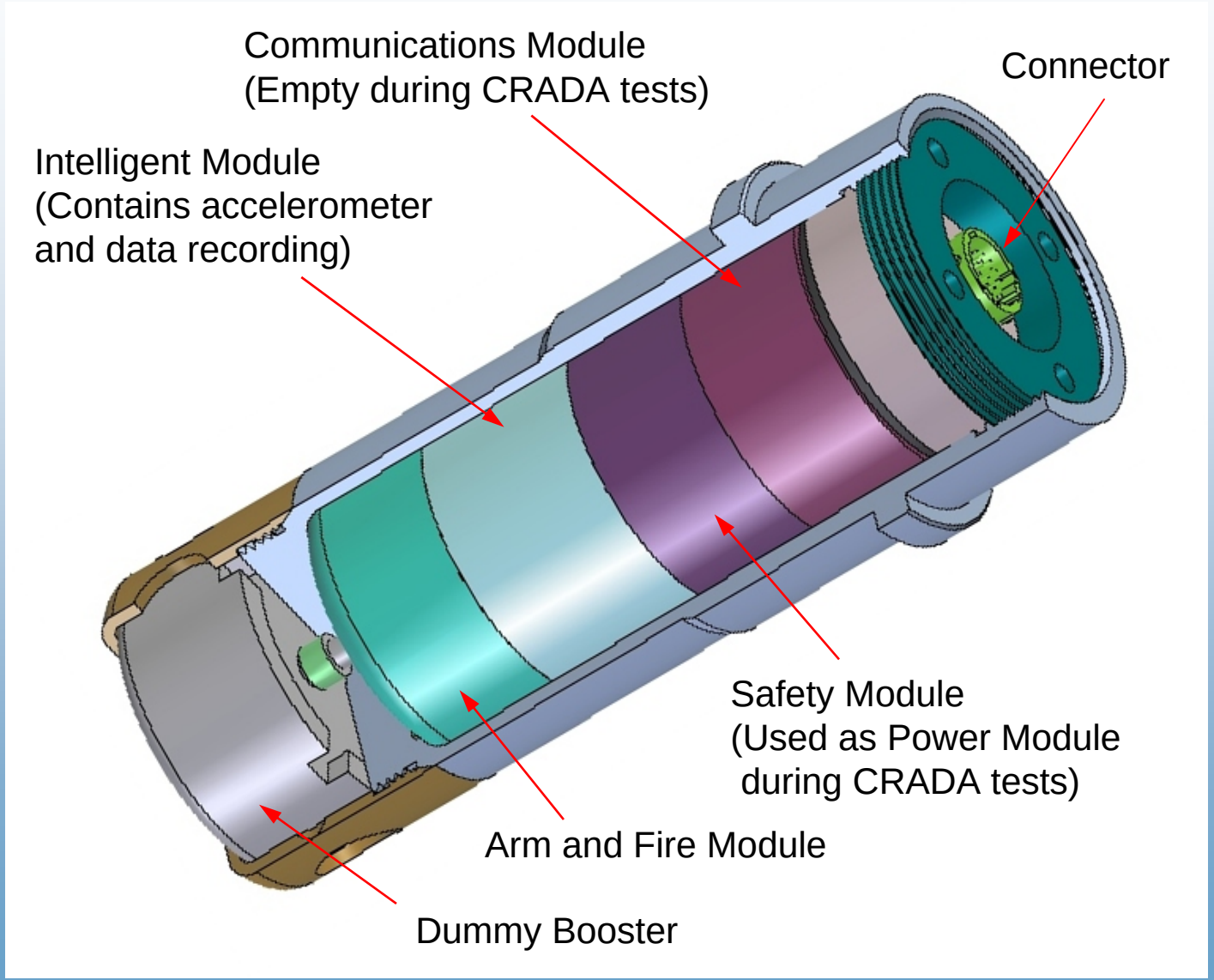
- In-house testing performed
  - Thermal shock
  - Mechanical shock
  - Air gun tests
- 1st howitzer test series performed
- Design updates made



Final Design

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Design Overview
Final Configuration



1st Howitzer Test Series Results

- AFRL Howitzer tests – Jan 2008
  - 1st shot 9 inch, 5000psi
  - 2nd shot 2 ft thick target, 5000psi
  - 3rd shot 2ft thick target followed by another 2ft thick target, 5000psi
- Results
  - Same hardware fired in first two shots with inert LEEFI
    - Arm/Fire module survived and still functions
  - STUBBI projectile stuck in wall on third shot
    - Very high g impact
    - Live LEEFI fired

1st Howitzer Test Series Results



Shot #1

Shot #3



1st Howitzer Test Series Results

- Results Cont'd
  - Mechanical design proved to be robust.
    - Only mechanical failure was external connector broke free during impact
  - Main disappointment of the test was the inability to record data
    - Recorder reset due to main connector
    - Internal damage on 2nd & 3rd shots
  - Arm/fire module survived high g shock
    - No redesign required

Design Updates

- Mechanical design improvements made to 1st Iteration Hardware
  - Module – alignment feature changed for each cup to make more robust during impact
  - Fuze body was modified in order to use existing mounting hardware provided by AFRL
  - FOS engineering reports exist for each design improvement

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Design Updates

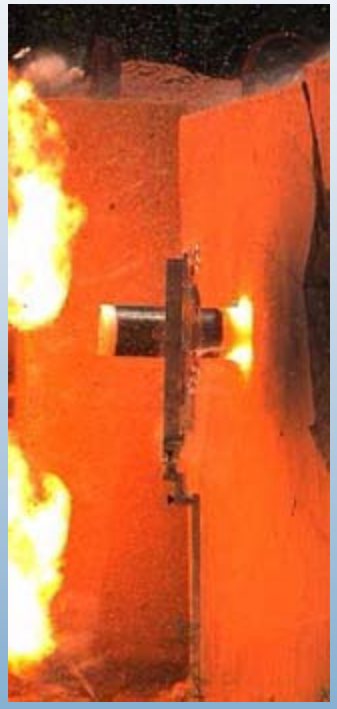
- Electrical Design Improvements made to 1st Iteration Intelligent Module
  - Major redesign
  - Changed microcontroller
  - Real-time data storage with non-volatile memory
  - Incorporated removable accelerometer module
    - Allows use of surface mount or screw mount accelerometers from multiple suppliers
  - These changes were derived from separate IRAD program for a standalone data recorder
    - Next paper provides information on FOS Data Recorder
  - Added Void sensing Algorithm provided by ARA

2nd Howitzer Test Series Results

- AFRL Howitzer tests – July 2008
  - 1st shot 2ft thick, 5000psi
  - 2nd shot 2ft thick, 5000psi
  - 3rd shot complex target, 9" wall, 3.5 ft air gap, 9" wall
- Results
  - Valid data retrieved from all analog and digital inputs
  - No damage to fuze structure, electronic modules and connector
  - The power module and intelligent module still functioned through main connector
  - Visual verification of LEEFI initiation
    - Recorder data showed LEEFI detonated at proper time

2nd Howitzer Test Series Results

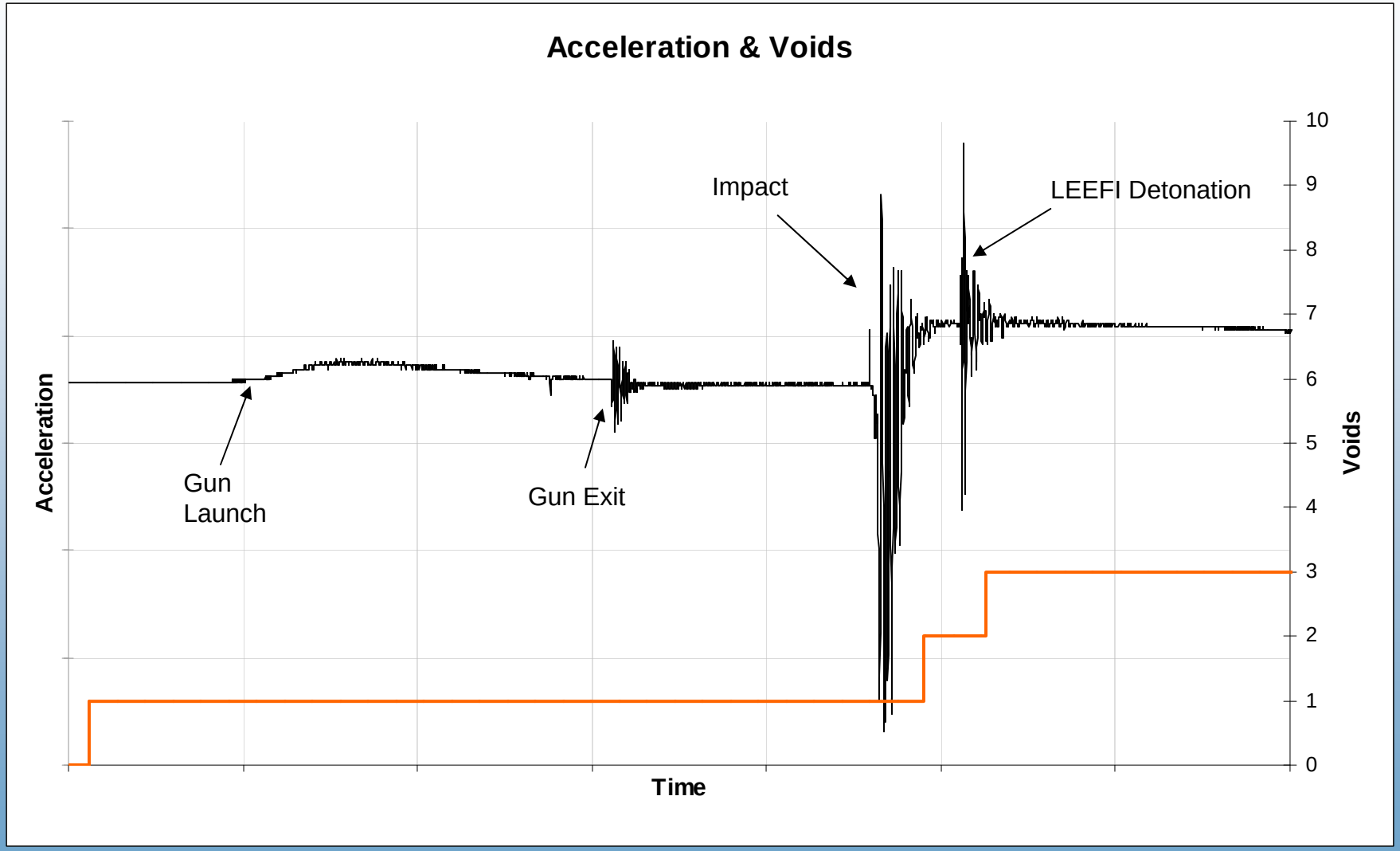






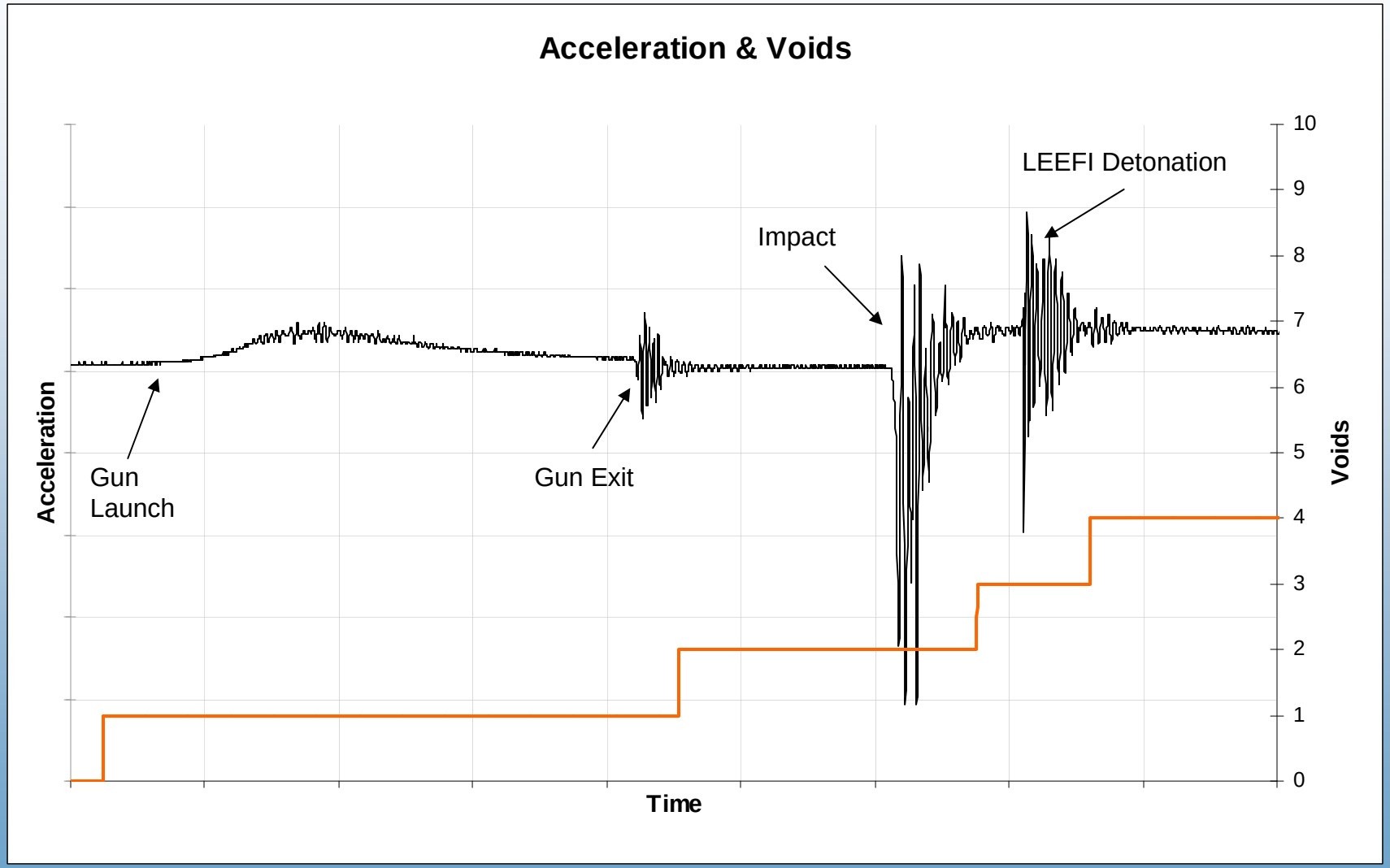
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2nd Howitzer Test Series Results
Shot #1



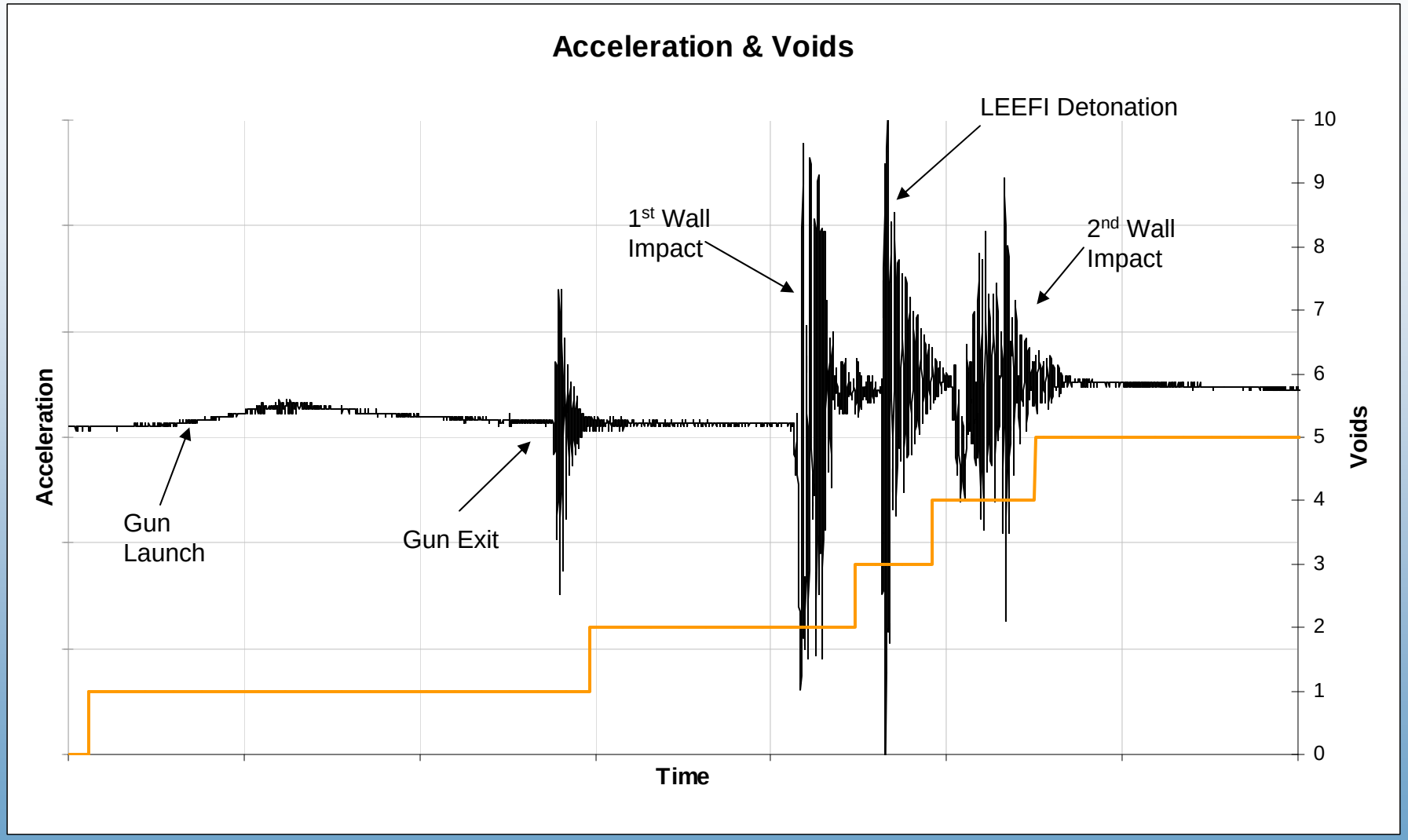
2ft thick, 5000psi

2nd Howitzer Test Series Results
Shot #2



2ft thick, 5000psi

2nd Howitzer Test Series Results
Shot #3



Complex Target, 9 inch target then 3.5 ft air then 9 inch target

CRADA Team Members

- L-3 FOS
  - Scott Colegrove
  - Noah Desch
  - Marc Worthington
  - Perry Salyers
  - Dave Lawson
- Eglin AFRL
  - Tim Tobik
  - Howard White
  - Kelly Oliver
  - Dick Mabry
  - Mark Lynch
  - Fuze Experimentation Facility Team
- ARA
  - John Perry
  - Ron Lundgren

Summary

- L-3 FOS developed a survivable Intelligent Penetrating Fuzing system with data recording and void/layer detection
- L-3 FOS has demonstrated the ability to provide a fuzing system for current and future requirements
- L-3 FOS Fuzing can provide for:
  - Functionality in high g complex targets
  - Ordnance data recording & void detection
  - Survivable "Next Generation" high velocity penetrating systems
- Initial intelligent module started the idea for a standalone FOS Data Recorder
  - Provides capability of redundant data collection in booster cup
    - See next paper for L-3 FOS Data Recorder Presentation

Rely on L-3 FOS to solve your ordnance problems

Fuzing & Ordnance Systems

L-3 FOS
3975 McMann Road
Cincinnati, Ohio 45245-2395

Development of a General Purpose Data Recorder for Very High Mechanical Shock Load Applications
May 21, 2009

Presented By

Marc Worthington, Mechanical Engineer

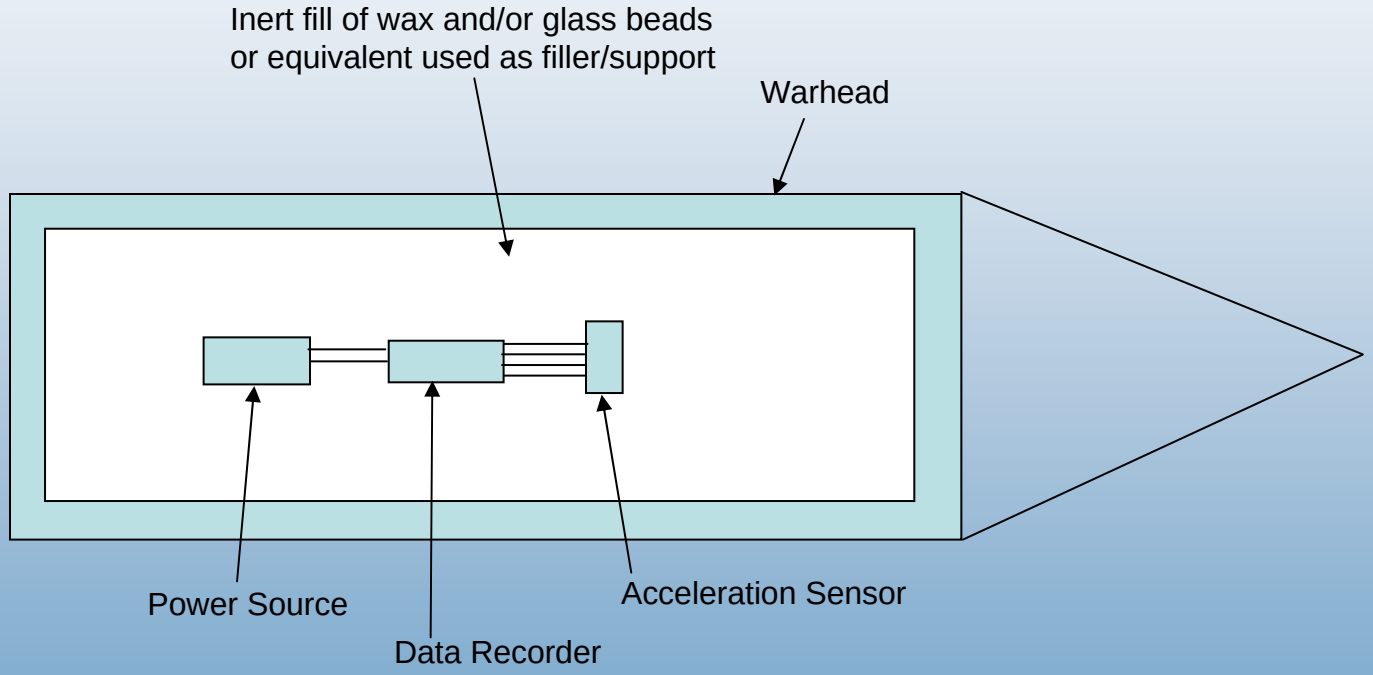
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Agenda

- Background
- Traditional Data Recorder Limitations
- Design
- Interface
- Event Capture & Triggering
- Test History
- Alternate Configuration
- Summary

Background

- Typical method used to obtain data from a high g test event



Problems with Typical Data Recording Method

- Data recorder and supporting hardware are placed in a munition as an "after thought"
  - Causes improperly supported assemblies
  - Increased risk of broken wires
  - Component damage
- Difficulty installing and controlling the supporting fill
  - Leads to possible movement of components
  - Causes broken components/wires.
- Failure of the external power source
  - Broken battery leads
  - Partial or total loss of data.
- Disassembly can cause component damage
  - Requires clean up due to potting
- Momentary/permanent loss of power
  - Volatile memory – Total data loss
  - EEPROM/Flash memory – Partial to total data loss
- Premature trigger events lead to incorrect data being recorded

These problems are addressed with the L-3 FOS design

Design Summary

- Design based on initial intelligent fuze recorder design
- Next generation modular data recorder
  - 3 axis acceleration measurement
  - Non-volatile memory
  - Real-time data storage
- New mechanical envelope
  - Includes 4 removable accelerometer modules
  - 2 inch diameter
  - Configured for tube launched systems

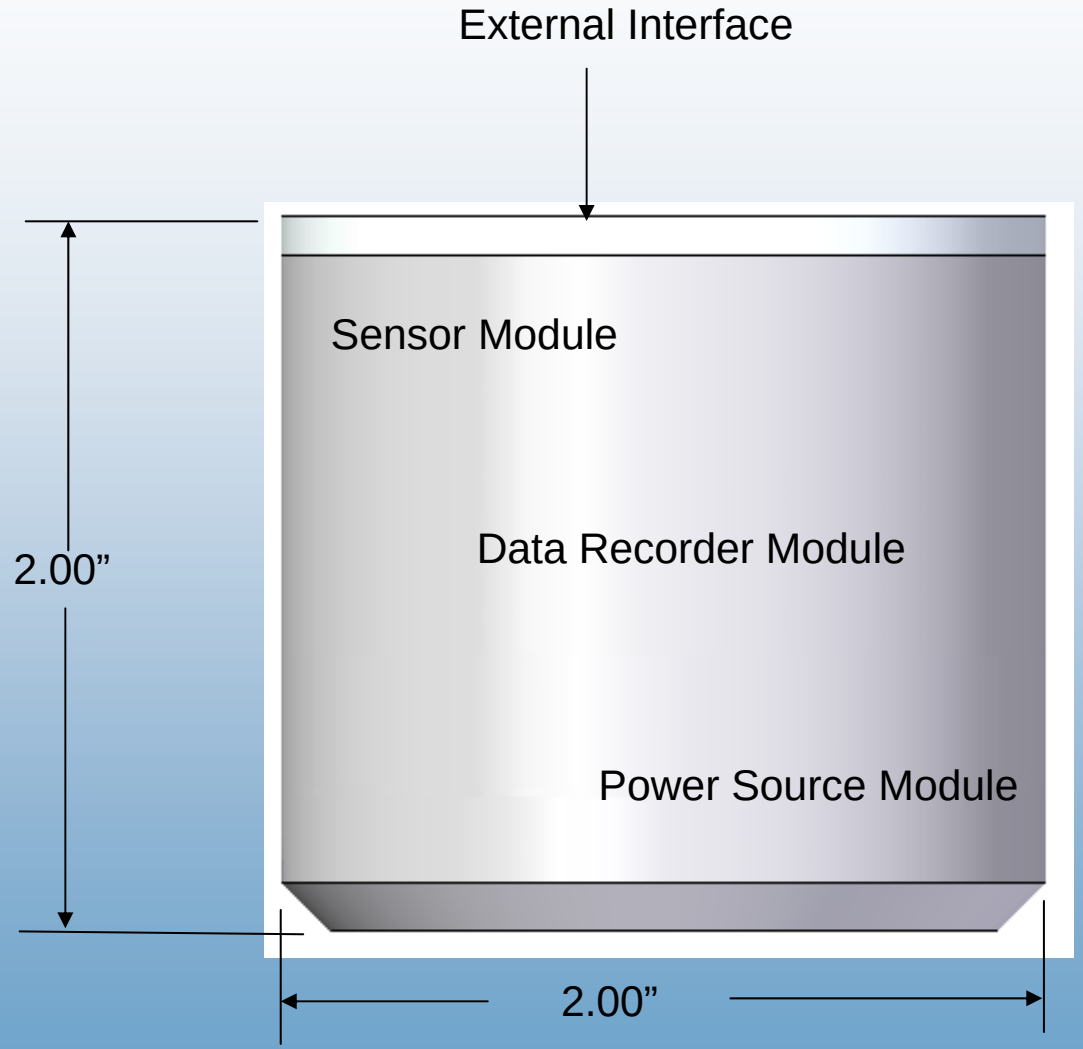
Patent Pending

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Design Features

- Analog Data Recording
  - 4 simultaneously sampled 10 bit analog channels
- Digital Data Recording
  - 4 simultaneously sampled digital channels
  - Sampled together with analog channels
- Multiple Triggering Options
- Fast Sampling Rate
  - User selectable rate
- Versatile
  - Adjustable pre-trigger position
  - PC Interface via RS422

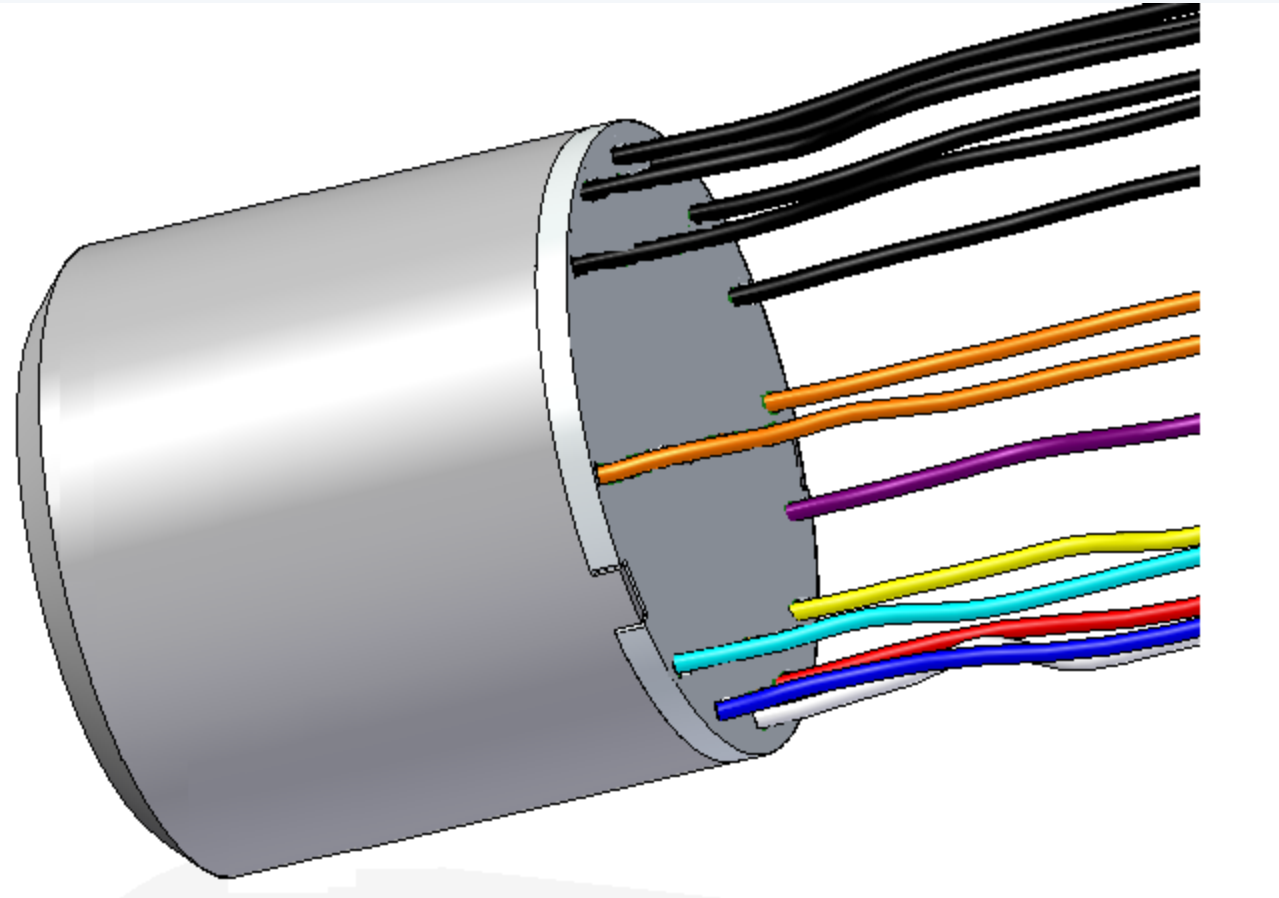
Mechanical Design, Envelope



Electrical Design

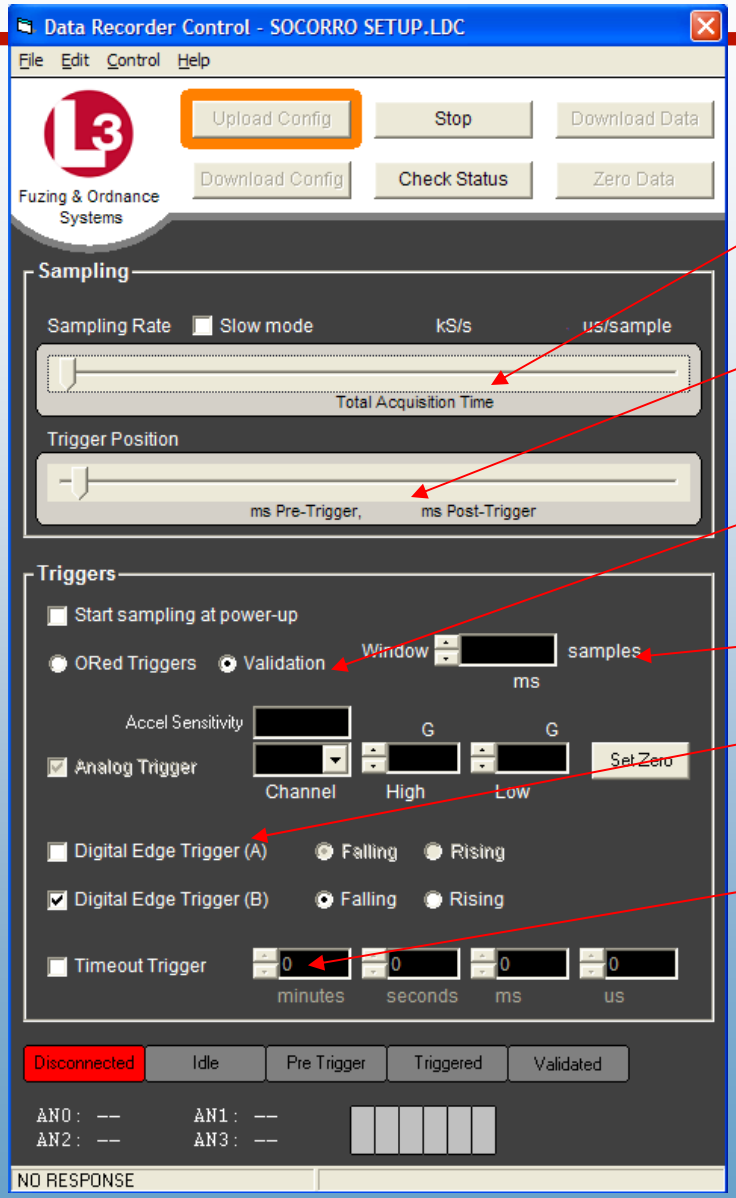
- Data recorder hardware contained in 3 separate modules:
  - Sensor Module:
    - Accelerometer(s)
    - Signal Conditioning
    - Power Conditioning
    - Analog and Digital signals passed through to data recorder
  - Data Recorder Module:
    - Microprocessor Based
    - Non-volatile Memory – memory stored in real-time
    - Input Buffers for analog and digital channels
  - Power Module:
    - Additional Energy Storage (capacitors, batteries…)

Mechanical Design, Application



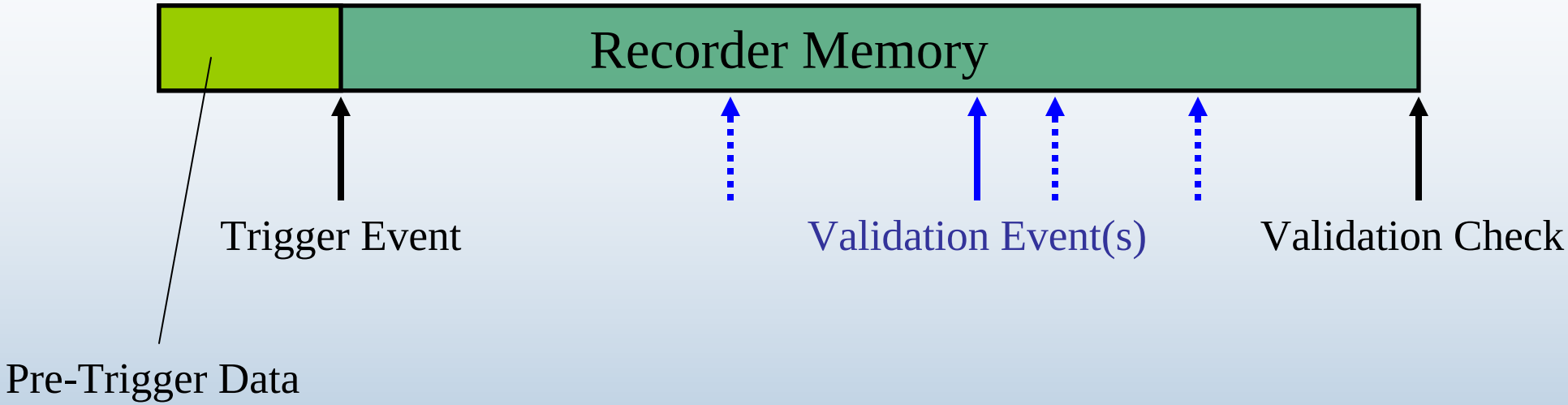
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Graphical User Interface (GUI)/Firmware



- Adjustable Sampling Rate
- Adjustable Trigger Point
- Trigger Validation Option
- Trigger Window
- Analog and digital triggering options
- Timeout Triggering

Trigger Validation Timeline



- Pre-trigger data recorded until a **Trigger Event** is detected
- Recording proceeds normally until memory is full
- If no validation event is detected, memory is cleared and recording starts back in pre-trigger mode
- Validation can be time-windowed with trigger

High Shock Testing History

- Data recorder proven to survive high g impacts
  - Multiple Stubbi/Howitzer tests up to 2 ft concrete and complex targets.
  - Artillery Shell Howitzer 9 inch concrete target
  - Multiple Sled Test/Warhead Test
  - Five Inch Gun Fired Tests
- Survived and data downloaded 2 months after projectile stuck in gun tube

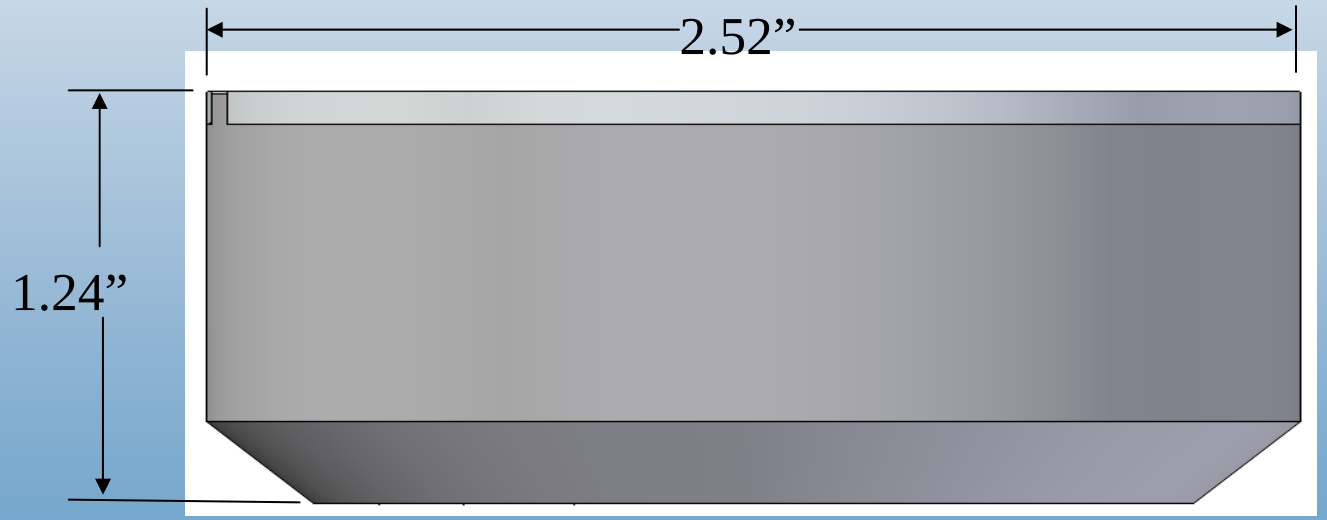
Specifications

- Device is functionally specified and tailorable to applications
- Data recorder data sheet pending public release
- Data sheet available upon request

Parameter	Description	Value		units
W1	Weight			lbs
				kg
Vdd	Supply voltage	**Min**	**Max**	volts
Idd	Supply current	**Typ**	**Max**	mA
Vin (min)	analog/digital input minimum voltage			volts
Vin (max)	analog/digital input maximum voltage			volts
Vth+	Digital input positive going threshold	**Max**		volts
Vth-	Digital input negative going threshold	**Min**		volts
Idin	Digital input max input current			µA

Alternate Configuration

- 2.5 Inch Data Recorder Design
  - Packaged to fit in a 3 Inch Booster Cup
  - Prototype testing in June of 2009



Summary

- L-3 FOS used its expertise in fuzing to develop a general purpose hardened data recorder
- L-3 FOS Data Recorder has been tested in applications >20kGs.
- L-3 FOS Data Recorder provides a:
  - Flexible launch diagnostic tool
  - Ordnance impact performance analysis tool
  - Survivable non-volatile data recorder
- L-3 FOS continues to expand its fuzing and development tool set

Rely on L-3 FOS to solve your ordnance problems

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GOVERNMENT INDUSTRY ENTERPRISE

Based on

OTHER TRANSACTIONS AGREEMENT FOR PROTOTYPE PROJECTS

And

THE NATIONAL COOPERATIVE RESEARCH AND PRODUCTION ACT

Presented at the

53rd ANNUAL FUZE CONFERENCE

MAY 20, 2009

by

DAROLD L. GRIFFIN

Engineering and Management Executives, Inc.

Alexandria, VA 22304

Telephone: (703) 212-8030 **E-Mail: eme1bmt@aol.com**

BACKGROUND

- **IN LATE 80s AND EARLY 90s THERE WAS A MAJOR EFFORT TO REDUCE THE COST OF DEFENSE WHILE TRYING TO MAINTAIN THE DEFENSE TECHNOLOGY BASE AND INDUSTRIAL BASE**
  - **ACQUISITION REFORM**
  - **SPECS AND STANDARDS BLUE PRINT FOR CHANGE**
  - **REVISIONS OF PARTS 12 AND 15 OF THE FAR**
  - **SECTION 845 OF THE 1994 NATIONAL DEFENSE AUTHORIZATION BILL AS AMENDED**

SECTION 845 OTHER TRANSACTIONS AGREEMENT (OTA) FOR PROTOTYPE PROJECTS

- **AUTHORIZED UNDER THE AUTHORITY OF SECTION 2371 OF TITLE 10, UNITED STATES CODE**
  - **SECTION 2371 IS PRIMARILY FOR GRANTS**
- **A MAJOR OBJECTIVE OF THE OTA FOR PROTOTYPING WAS TO:**
  a. **CONTRIBUTE TO A BROADENING OF THE TECHNOLOGY AND INDUSTRIAL BASE AVAILABLE FOR MEETING DEPARTMENT OF DEFENSE NEEDS AND**
  b. **FOSTER WITHIN THE TECHNOLOGY BASE NEW RELATIONSHIPS AND PRACTICES THAT SUPPORT THE NATIONAL SECURITY OF THE UNITED STATES**
- **THIS IS THE ENABLING LEGISLATION TO CONTRACT WITH CONSORTIA SUCH AS THE NATIONAL WARHEADS AND ENERGETICS CONSORTIUM AND THE NATIONAL SMALL ARMS TECHNOLOGY CONSORTIUM**

OTHER TRANSACTIONS AGREEMENT (OTA) FOR PROTOTYPE PROJECTS

- **A LEGALLY BINDING INSTRUMENT FOR:**
  - **BASIC AND APPLIED RESEARCH AND DEVELOPMENT**
  - **PROTOTYPES DIRECTLY RELEVANT TO WEAPONS OR WEAPON SYSTEMS TO BE ACQUIRED BY DOD**
  - **EARLY PRODUCTION OF ITEMS DEVELOPED UNDER PROTOTYPE CONTRACTS**
- **OTAs ARE TYPICALLY MULTI-PARTY WITH COMPANIES AND UNIVERSITIES IN PARTNERSHIPS , JOINT VENTURES OR CONSORTIA**
- **OTAs ARE EXEMPT FROM FAR AND MOST OTHER ACQUISITION LAWS AND REGULATIONS**
- **INDIVIDUAL PROJECTS MAY BE FUNDED TO $25 MILLION UNDER LOCAL PROCUREMENT AUTHORITY**

NATIONAL COOPERATIVE RESEARCH AND PRODUCTION ACT

- **THE NATIONAL COOPERATIVE RESEARCH AND PRODUCTION ACT WAS PASSED IN 1993 TO ENCOURAGE TECHNICAL JOINT VENTURES AND CONSORTIA**
- **THE LAW:**
  - **IS INTENDED TO PROMOTE INNOVATION, FACILITATE TRADE AND STRENGTHEN COMPETITION OF THE U.S. IN WORLD MARKETS THROUGH JOINT VENTURES OR CONSORTIA**
  - **NOTIFICATION OF THE DEPARTMENT OF JUSTICE (DOJ) AND THE FEDERAL TRADE COMMISSION (FTC) AS SET FORTH IN THE LAW LIMITS CIVIL ANTI-TRUST LIABILITIES**
  - **COVERS RESEARCH THROUGH FULL SCALE PRODUCTION**

COMMON THEME OF RELATIONSHIPS WITH INDUSTRY AND ACADEMIA

- **CREATE AND SUSTAIN A CRITICAL MASS OF SCIENTISTS AND ENGINEERS IN IMPORTANT TECHNOLOGY AREAS**
- **CREATE A FORUM FOR NATIONAL COOPERATION, COLLABORATION AND PARTNERING WITH INDUSTRY AND ACADEMIA**
- **ENHANCE TECHNOLOGY TRANSFER / INFORMATION EXCHANGE**
- **PROVIDE ACCESS TO GOVERNMENT FACILITIES AND INTELLECTUAL PROPERTY**
- **DEVELOP**
  - **A BETTER UNDERSTANDING OF REQUIREMENTS**
  - **A VEHICLE ATTRACTIVE TO DEFENSE AND NON-DEFENSE COMPANIES**
  - **LONG TERM RELATIONSHIP - AT LEAST 5 YEARS**
  - **COMMERCIAL CONTRACT TERMS**
- **PROJECT AWARDS THAT ARE PRIVATE, SIMPLE AND FREE OF FAR CLAUSES**

EXECUTION OF RELATIONSHIP
CONSORTIA OF INDUSTRY AND ACADEMIA

- **DEFENSE ENCOURAGES INDUSTRY AND ACADEMIA TO FORM CONSORTIA UNDER THE NATIONAL COOPERATIVE RESEARCH AND PRODUCTION ACT (NCRPA) OF 1993, AS AMENDED**

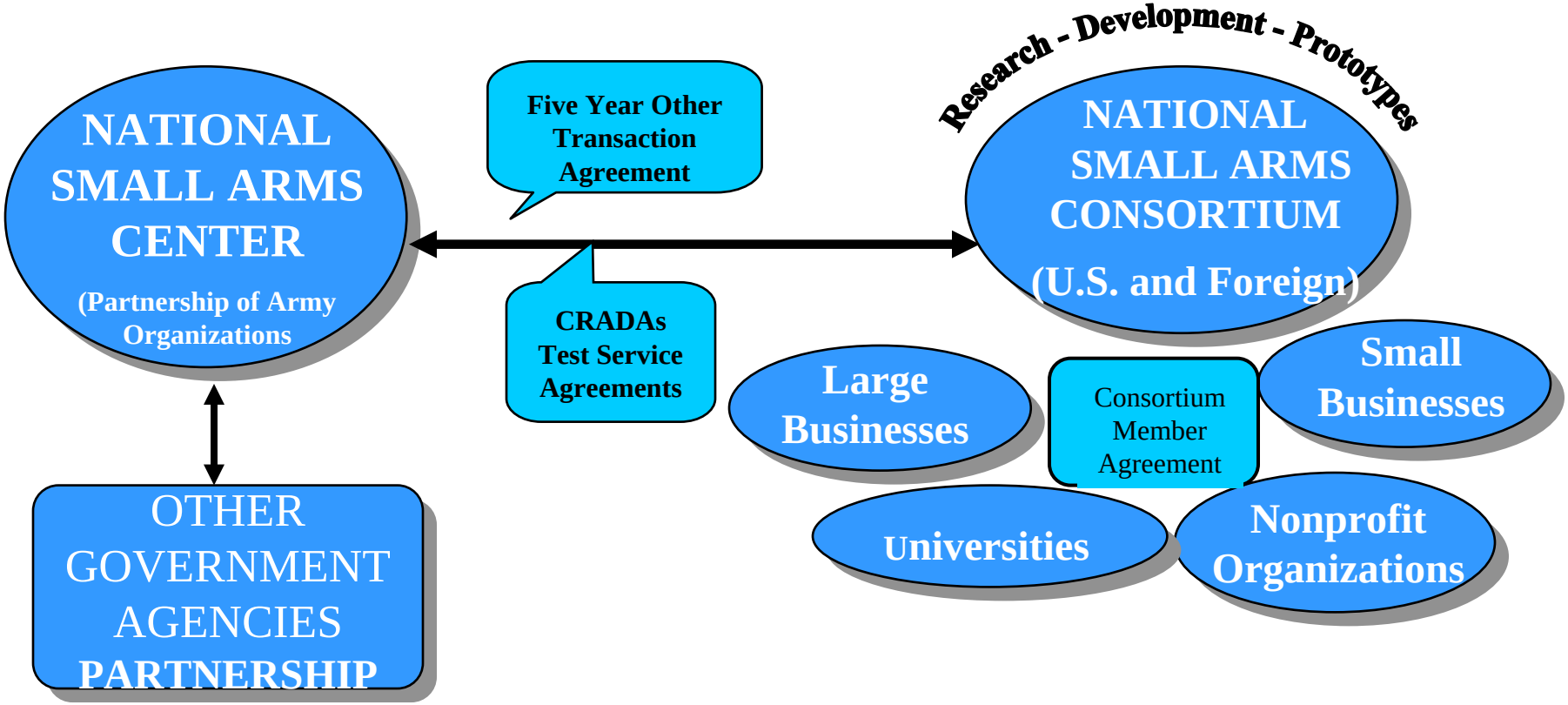
- **EACH CONSORTIUM DEVELOPS A CONSORTIUM MEMBER AGREEMENT WITH THESE PRINCIPLES:**
  - **MEMBERSHIP IS CONTINUOUSLY OPEN TO ALL QUALIFIED APPLICANTS**
  - **CONTAINS THE BASIC AGREEMENT AMONG THE MEMBERS FOR GOVERNANCE, INTELLECTUAL PROPERTY, RISKS AND RESPONSIBILITIES AND PROTECTION OF CONFIDENTIAL INFORMATION**
  - **REQUIRES DISPUTES TO BE RESOLVED BY ARBITRATION**

- **DEFENSE CONTRACTS WITH THE CONSORTIUM MEMBERS THROUGH A MASTER OTA**

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ORGANIZATIONAL CONCEPT

US ARMY NATIONAL SMALL ARMS CENTER



MANAGEMENT

- **AN EXECUTIVE COUNCIL OF INDUSTRY AND GOVERNMENT EXECUTIVES TO PROVIDE OVERSIGHT OF THE CENTER AND CONSORTIUM**
- **A RESEARCH COMMITTEE AND SUBCOMMITTEES OF GOVERNMENT AND INDUSTRY SCIENTISTS / ENGINEERS TO ESTABLISH AND PRIORITIZE THE TECHNOLOGY PROGRAM AND ASSESS PROGRESS**
- **A GOVERNMENT RESEARCH DIRECTOR TO MANAGE THE DAY-TO-DAY TECHNICAL BUSINESS OF THE CENTER AND CONSORTIUM**
- **AN EXECUTIVE DIRECTOR OF THE CONSORTIUM TO MANAGE THE CONSORTIUM'S ADMINISTRATIVE FUNCTIONS**
- **AN EFFECTIVE PROJECT MANAGEMENT STRUCTURE DEVELOPED COOPERATIVELY WITH INDUSTRY AND ACADEMIA**

THE BENEFITS

- **RAPID TECHNOLOGY DEVELOPMENT AND TRANSITIONING OF PRODUCTS TO THE FIELD**
- **PARTNERING AND TEAMING ARRANGEMENT**
- **LEVERAGING RESOURCES AND ASSETS:**
  - **PRIVATE SECTOR**
  - **GOVERNMENT**
- **TECHNOLOGY TRANSFERS BETWEEN DEFENSE AND CONSORTIUM MEMBERS AND AMONG CONSORTIUM MEMBERS**
- **QUICK AND FLEXIBLE MEANS TO AWARD AGREEMENTS (CONTRACTS)**
- **INCREASED FUNDING FOR RESEARCH, DEVELOPMENT AND PRODUCTION**

THEN COMES SECTION 803, CLARIFICATION AND EXTENSION OF AUTHORITY TO CARRY OUT CERTAIN PROTOTYPE PROJECTS

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SECTION 803

- **APPROPRIATE USE OF OTA AUTHORITY**
  - **THERE MUST BE AT LEAST ONE NON-TRADITIONAL DEFENSE CONTRACTOR PARTICIPATING TO A SIGNIFICANT EXTENT IN THE PROTOTYPE CONTRACT OR**
  - **AT LEAST ONE THIRD OF THE TOTAL COST MUST BE PAID BY THE CONTRACTOR OR**
  - **A SENIOR PROCUREMENT OFFICIAL DETERMINES THAT EXCEPTIONAL CIRCUMSTANCES JUSTIFY THE USE OF THE TRANSACTION THAT PROVIDES AN INNOVATIVE BUSINESS ARRANGEMENT OR STRUCTURE**

- **DEFINED NON-TRADITIONAL CONTRACTOR**
  - **AN ENTITY THAT HAS NOT FOR A PERIOD OF AT LEAST ONE YEAR**
    - **PERFORMED A CONTRACT SUBJECT TO FULL COVERAGE UNDER THE COST ACCOUNTING STANDARDS**
    - **ANY *CONTRACT* IN EXCESS OF $500,000 TO CARRY OUT A PROTOTYPE PROJECT OR PERFORMED BASIC, APPLIED OR ADVANCED RESEARCH PROJECTS FOR A FEDERAL AGENCY**

THE SECTION 803 EVOLUTION

- **USE SINGLE POINT CONTRACTING**
  - **GOVERNMENT AWARDS MASTER OTA TO CONSORTIUM AS OPPOSED TO ITS MEMBERS**
  - **CONSORTIUM MANAGEMENT SELECTS A THIRD PARTY AGENT (SUBJECT TO GOVERNMENT APPROVAL) TO NEGOTIATE, AWARD AND MANAGE THE SUBAGREEMENTS**

- **HOWEVER, GOVERNMENT PROCUREMENT AND SINGLE POINT AGENT HAVE ADOPTED A FAR-LIKE PROCESS TO NEGOTIATE AND AWARD SUBAGREEMENTS:**
  - **TIME CONSUMING**
  - **REQUIRES LOTS OF COST AND BUSINESS DETAILS**
  - **MAY JEOPARDIZE USE OF OTA FOR PROTOTYPING**

- **NOW THERE'S A BACKLASH FROM MEMBERS**

BOTTOM LINE: KEEP THE PRESSURE ON!

NAVSEA
WARFARE CENTERS
INDIAN HEAD

Variable Acceleration Profiling and Characterization of S&A Escapement Mechanisms

Michael Deeds, PhD
Alex Cox
Indian Head Division Naval Surface Warfare Center
Indian Head, MD

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DoD ENERGETICS CENTER
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Rotary Tables

Standard tool in the measurement of escapement mechanism arming distance

- Capable of applying long duration acceleration loads
- Related to tactical performance through escapement theory
  - Devices assumed to be distance measurement mechanism
  - Distance = ½ at^2
- Commonly used as part of escapement device acceptance tests

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Standard Rotary Tables Limitations

- Not all devices follow escapement theory to the desired accuracy
- Fails to provide data on setback lock release
- Difficulty in indexing from specific event (e.g., setback lock release)
- For M427 family of devices, biases rotor towards the arm position
- Incapable of applying variable G loads

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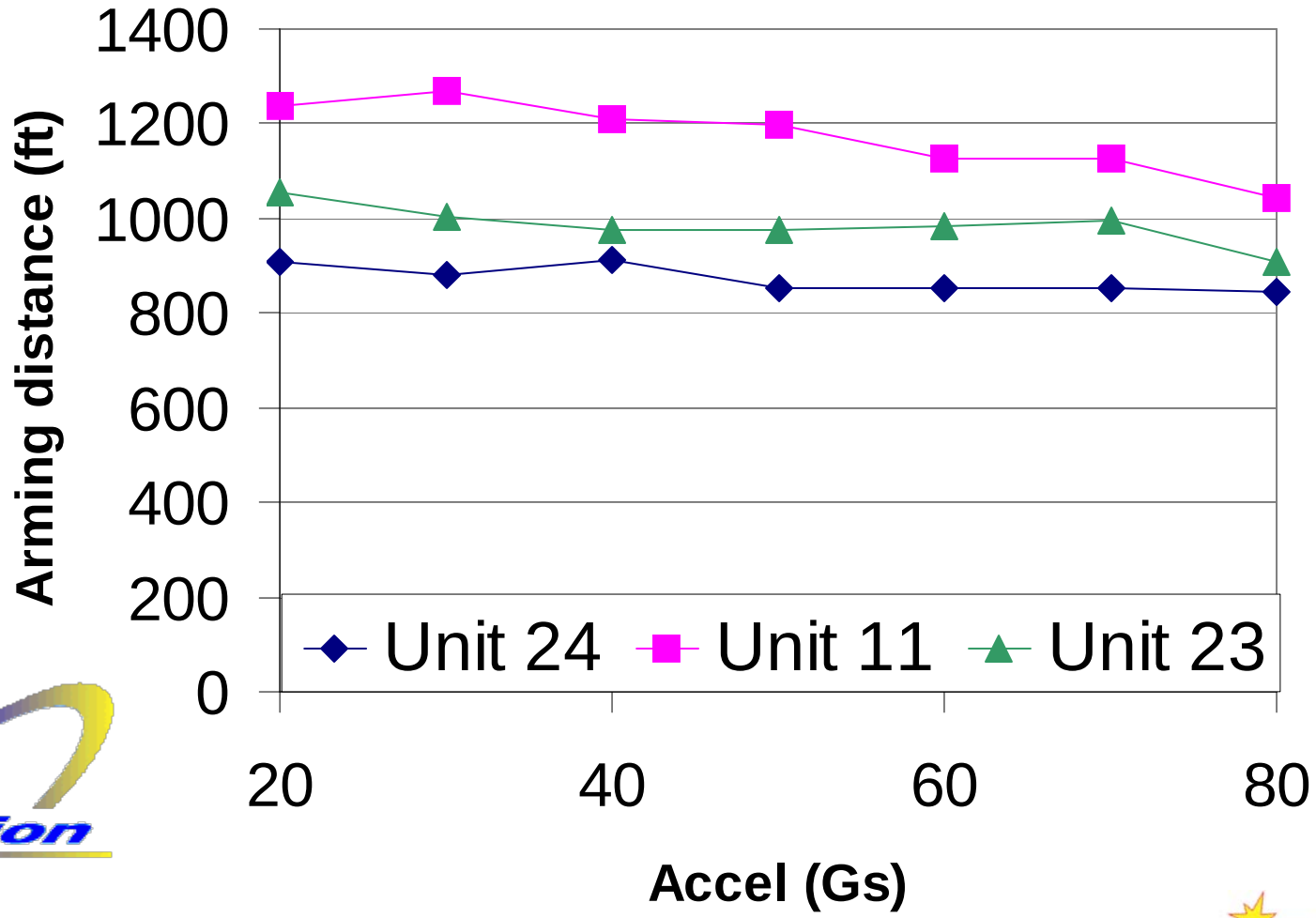
40G Acceptance Testing
Constant Acceleration Acceptance

- Acceptance test calls for a constant 40G stimulus be applied to the mechanism
- Setback weight is held until rotary table is at speed
- Weight is released and the mechanism is timed
- Acceptance determined via times in specification



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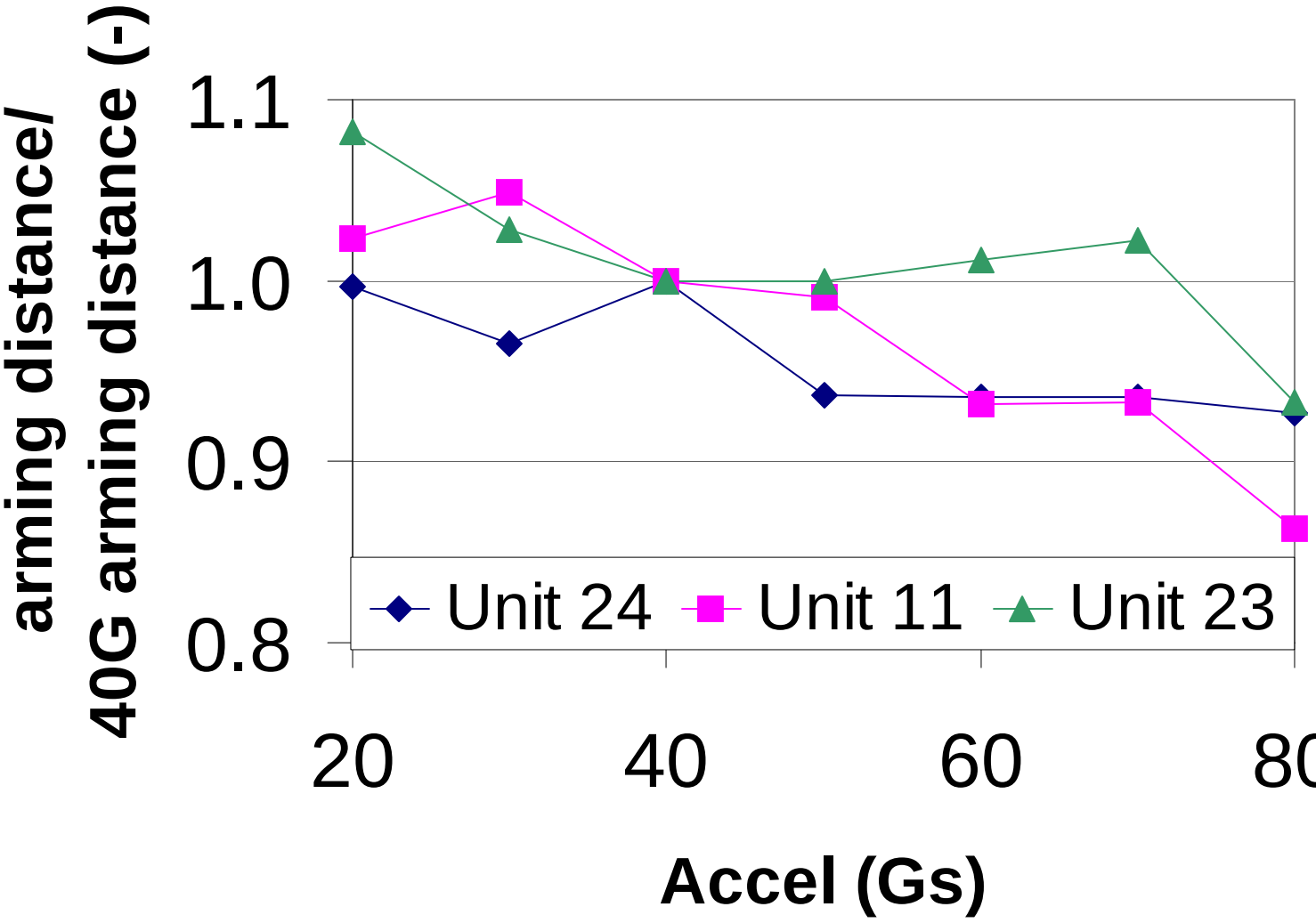
Device Arming Under Constant Load
Effect of Load on Arming Distance



Data courtesy of Action Manufacturing

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Device Arming Under Constant Load
Effect of Load on Arming Distance



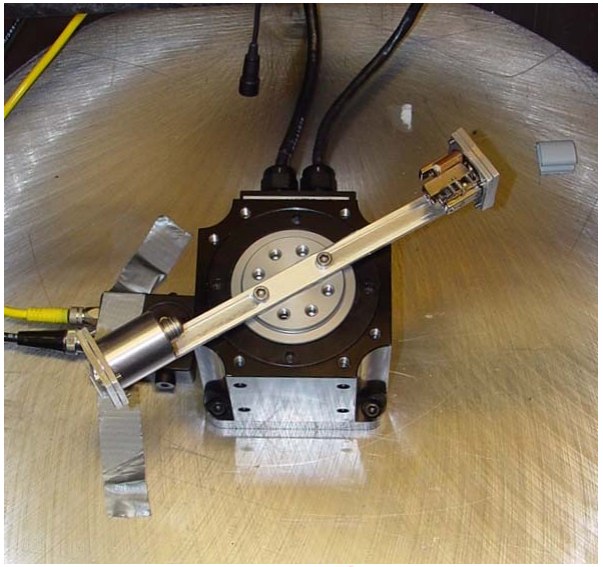
Load affects arming distance by as much as 10%

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Programmable Rotary Tables

- Allow the user to input desired positional coordinates and time history
- Resulting program can more accurately reproduce the tactical environment acceleration history



- Microphone allows for timing of critical events, such as environmental lock release

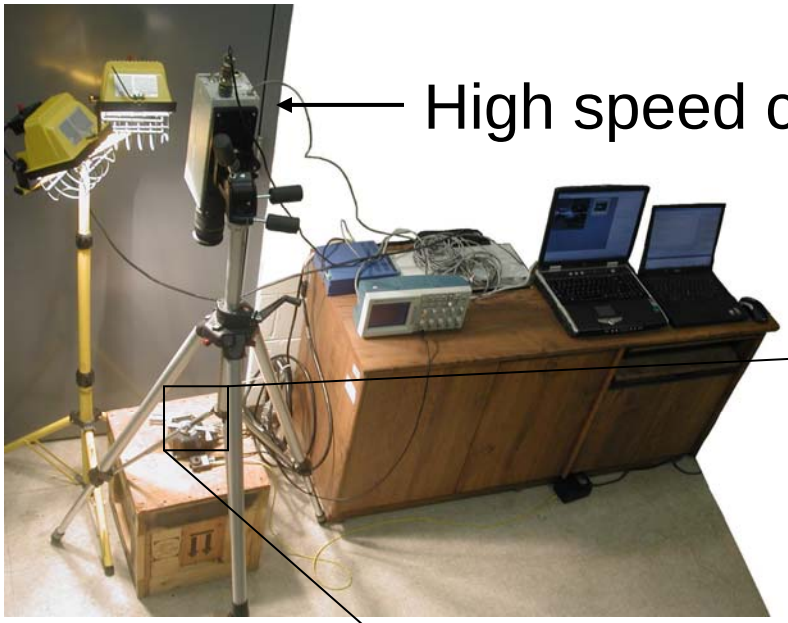
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Programmable Rotary Tables Limitations

- Inertia of device under test must be sufficiently small to allow table to track desired profile
- A tangential load is imparted to the device as table changes velocity
- Longer arm length is desirable for reduced error, but is limited by motor torque

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Programmable Rotary Table



High speed camera

Device under test

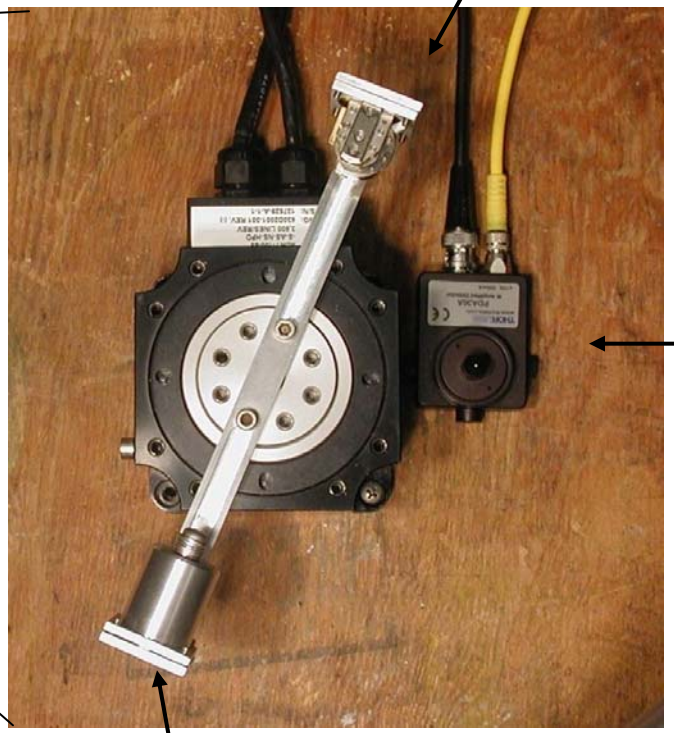


Photo detector

Table: ADRT-100-85’
Arm length: ~3.5”
Test item weight: ~.11lbs

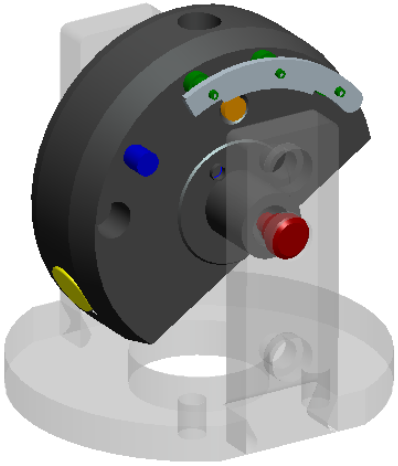
Ballast

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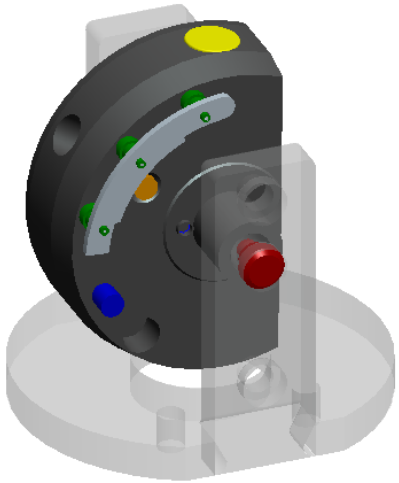
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Device Under Test

- Testing was conducted on the M427 S&A
- Part of Navy's 2.75 inch rocket system
- Setback Weight extracts around 15 to 20Gs
- Mechanism arms: 1.13 to 1.37 sec (or 817-1218 feet of rocket thrust)



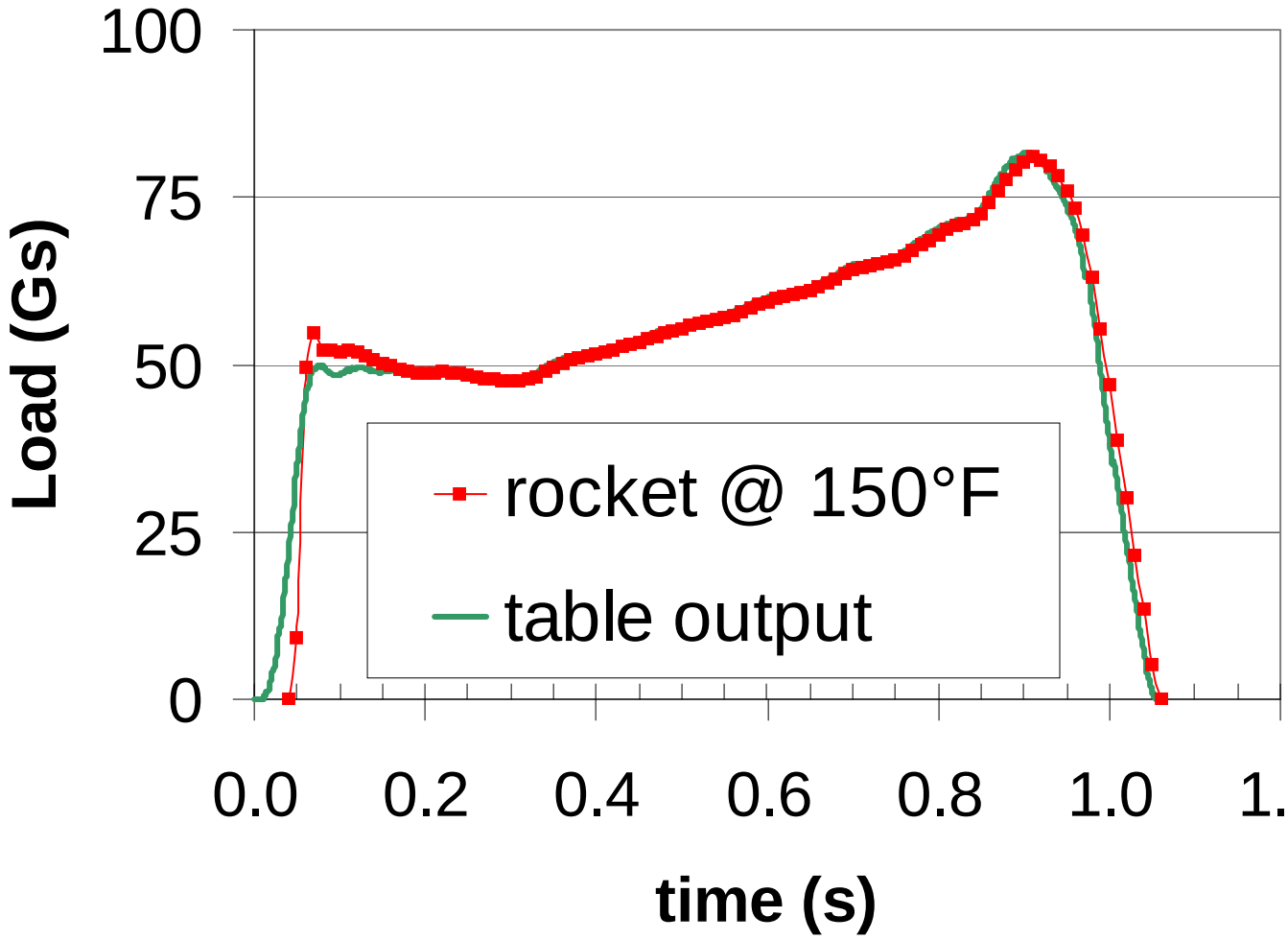
Safe



Armed

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Programmable Table Replication of Tactical Acceleration Environment



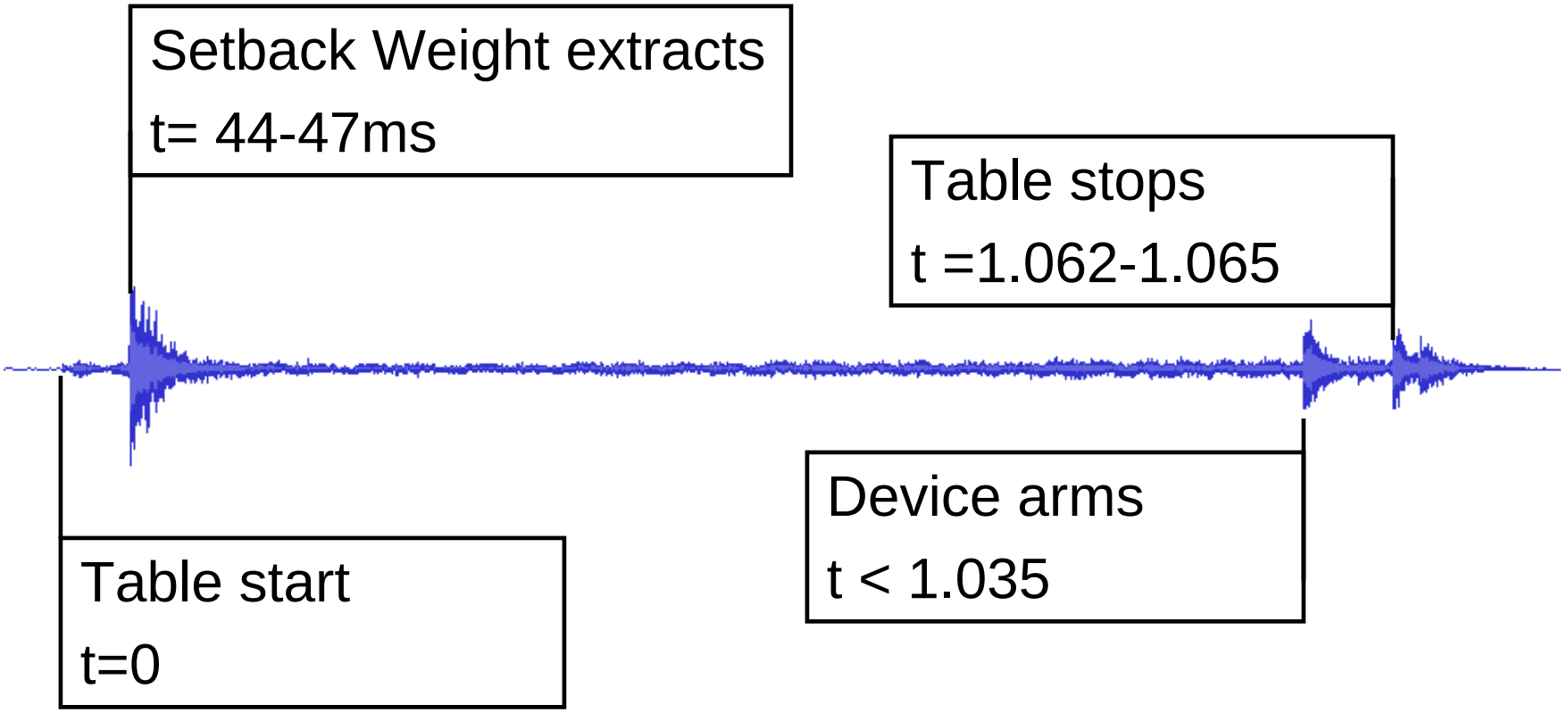
Impulse error: 0%

Distance error: 0.3%

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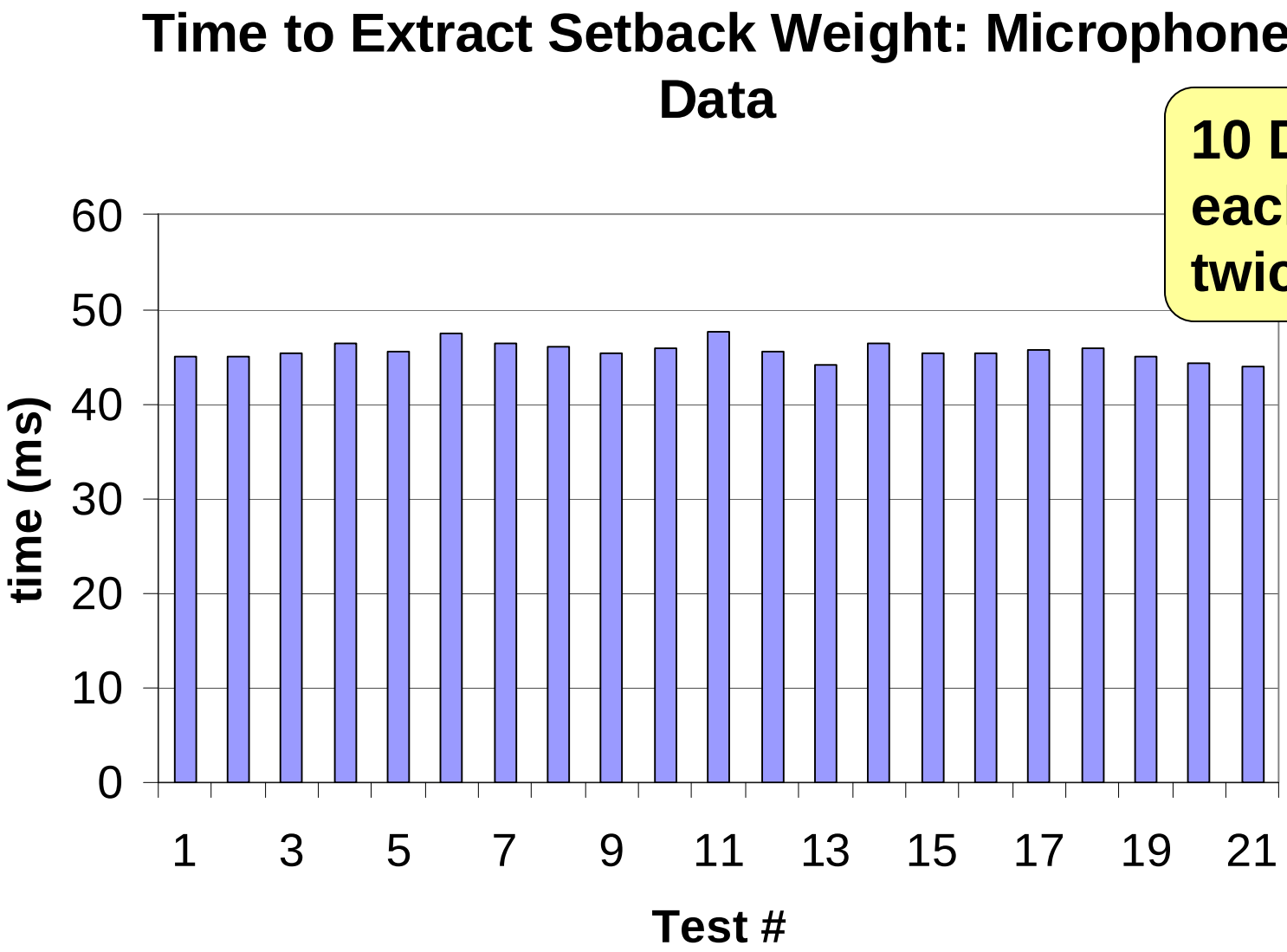
Acoustic Trace from Device Armed on Rotary Table



Setback weight and arming events can be timed via a microphone

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Setback Weight Instrumentation



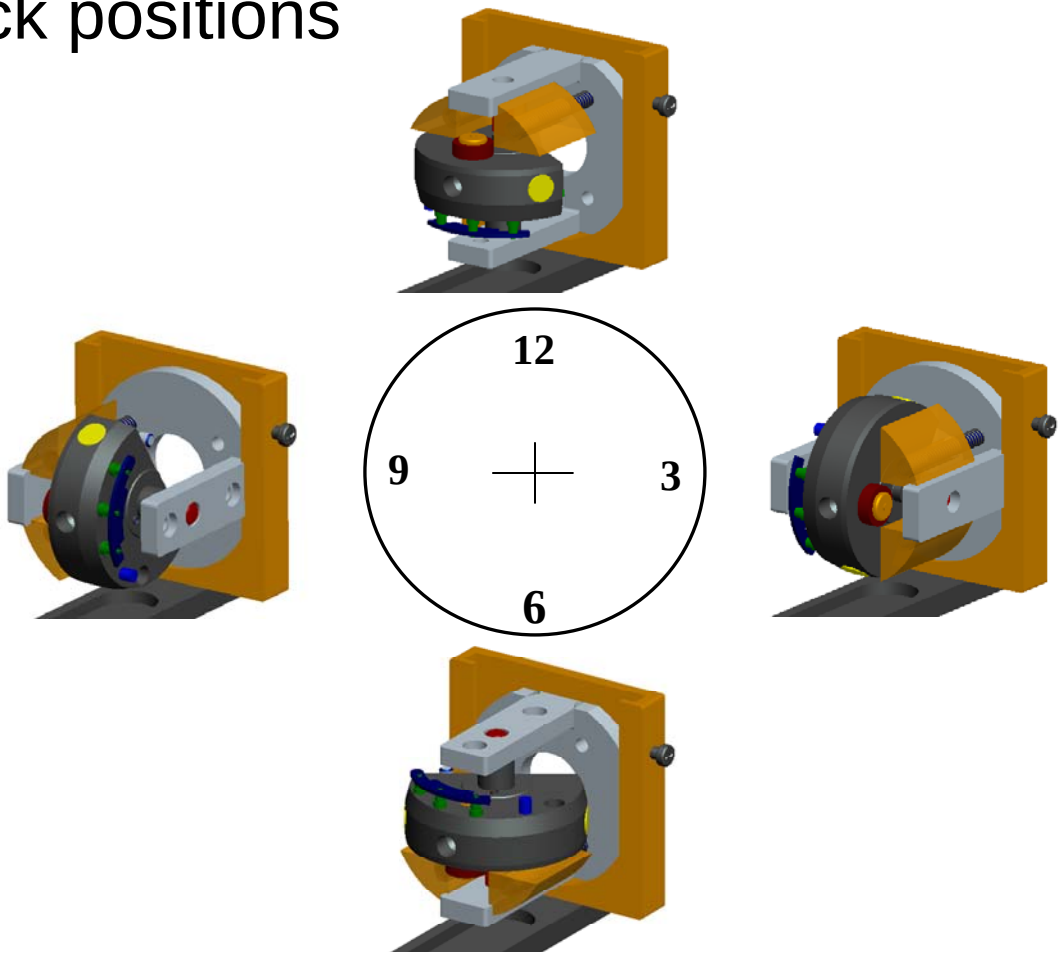
Device and test method repeatable

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Tangential Acceleration Effects

- Device static position in fixture was adjusted such that timing test was performed with setback weight at 12, 3, 6, and 9 o'clock positions



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Tangential Acceleration Effects

- Device timing consistent for a given orientation: <20ms (36’)
- Device timing varied based on change in initial orientation: <53ms (95’)
- Devices in 12 o’ clock armed 30 – 60ft faster than in 6 o’clock position (44’ expected from inertial effects)
- Devices in 3 and 9 o’clock distances varied depending on device, up to 70’ (0’ expected from inertial effects)

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Instrumented Rocket Tests

- Device to be spun in the lab using constant 40G and programmable rotary table tests
- Devices will be flown on instrumented rocket tests
  - Record arming time during flight
  - Record rocket acceleration history
- Provide correlation between field and lab simulation

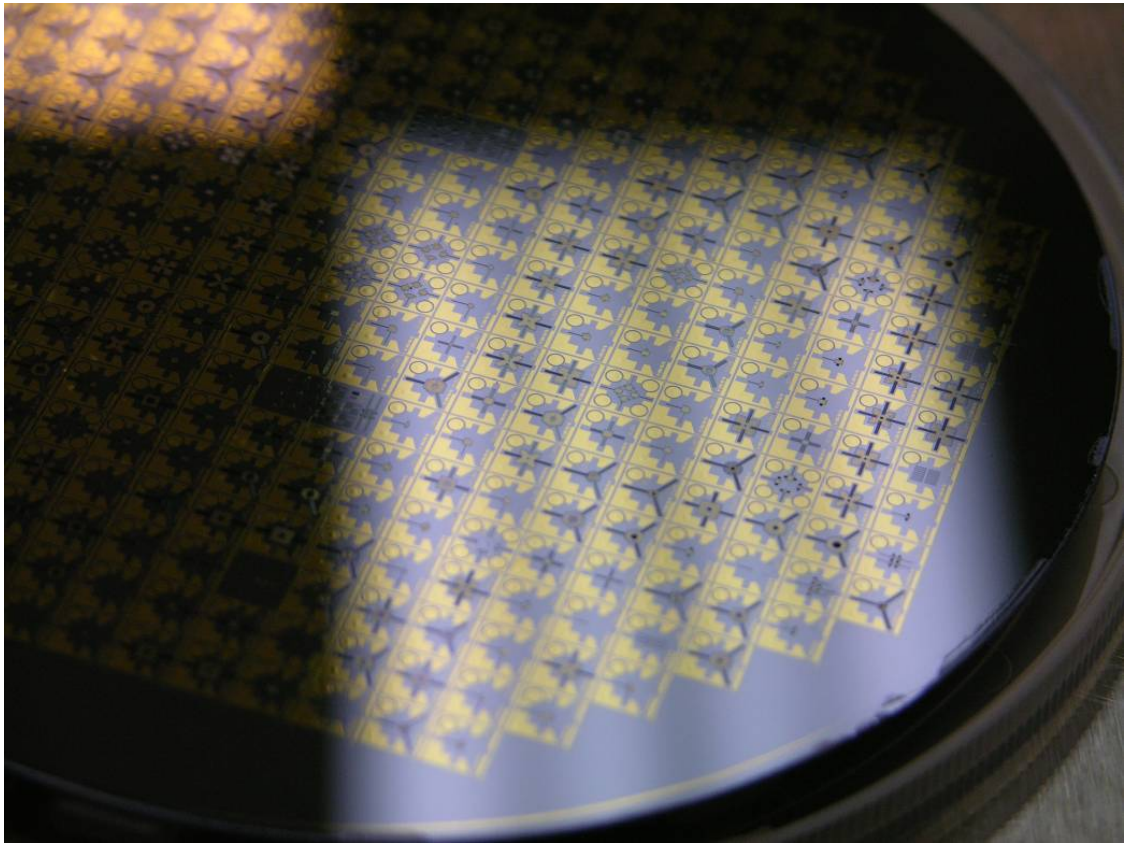
Distribution Statement A: Approved for Public Release

Summary

- Programmable rotary table has sufficient frequency response to replicate acceleration environment for fuzing applications
- Provide additional insight into mechanism status during deployment
- Alternative acceptance test, and in some cases more accurate, compared to the constant 40G test

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MEMS Impact Sensor



Daniel Jean, Ph.D.
Ezra Chen

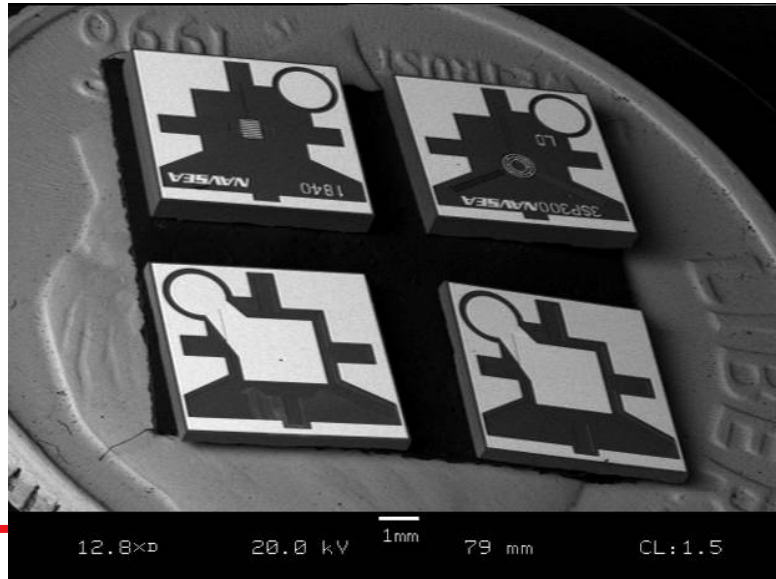
Naval Surface Warfare Center
Indian Head, MD USA

21 May 2009

Distribution Statement A: Approved for public release, Distribution unlimited, IHDIV

Contact Switch for Point Detonation

- Purpose: impact sensor for air burst round
- Trigger between 90 and 150 G
- Current snap dome sensor too large and inaccurate
- New contact switch must be low profile: less than 900 µm tall
- 2 rounds of design and fabrication completed in 2007
  - 60 sensors delivered
- 1 round of design and fab in 2008, 15 sensors delivered

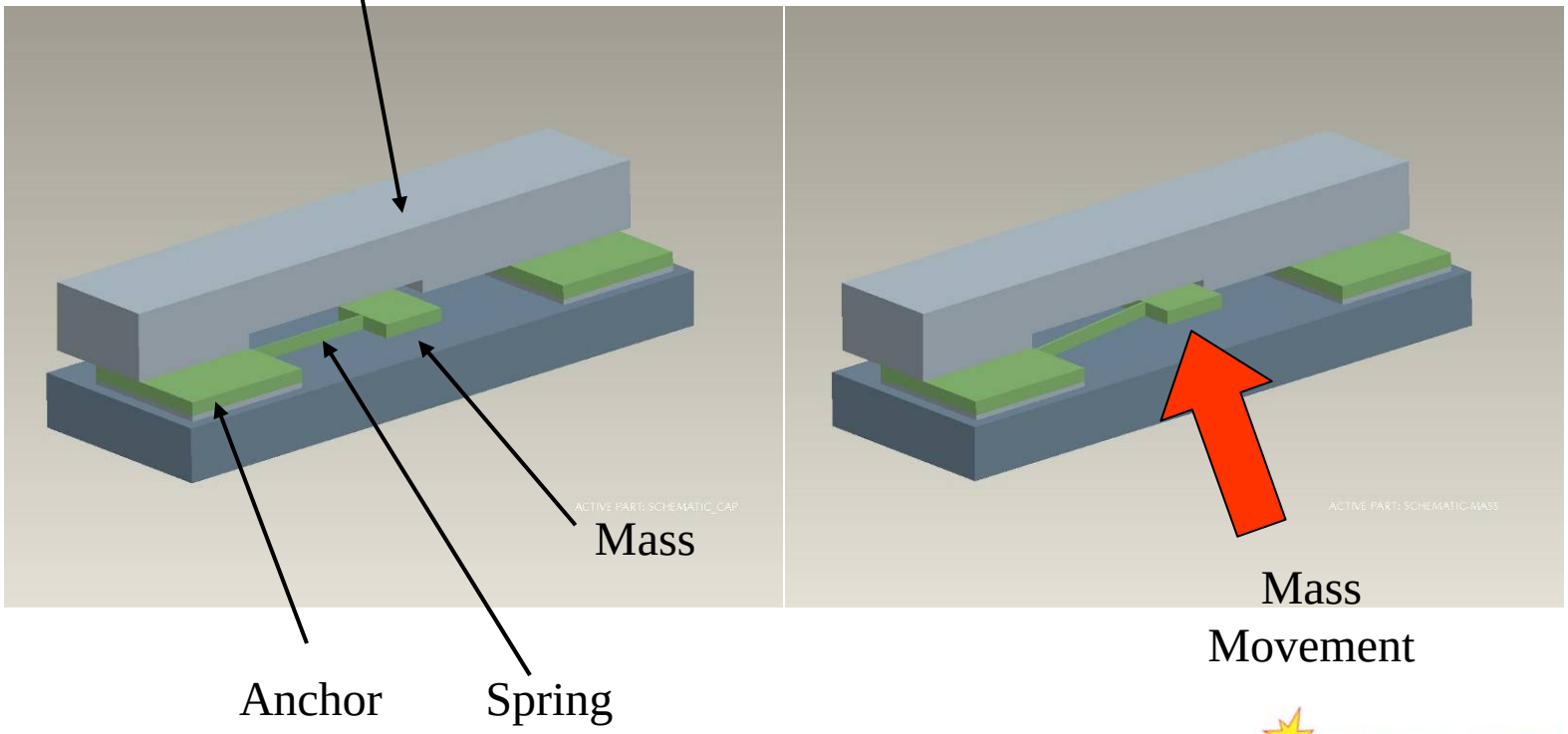


Contact Switch Schematic

Out-of-Plane Configuration

Threshold Sensor:

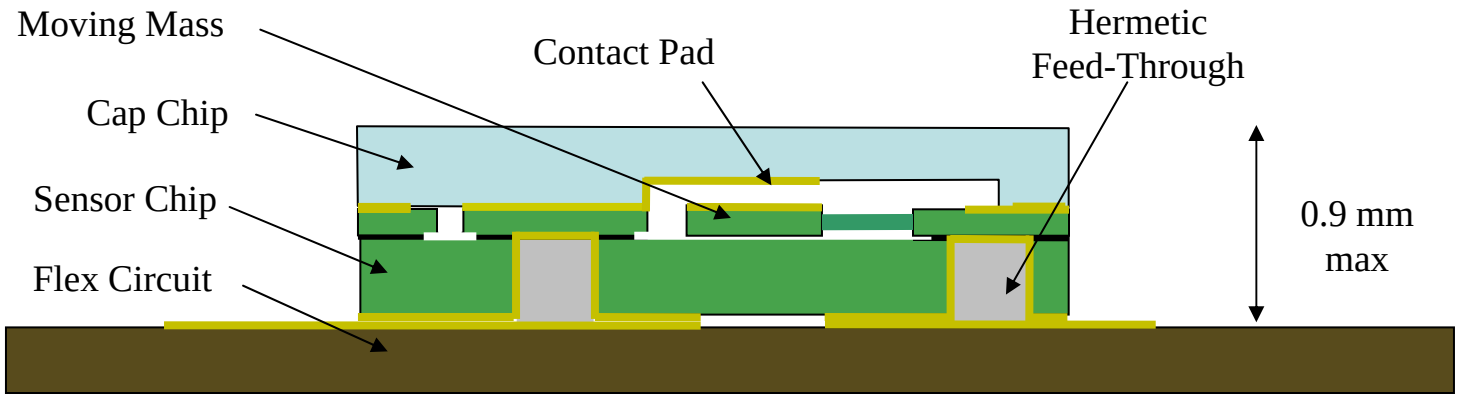
- Impact and shock
- Mass moves
- Switch closes
- Shock event ends
- Switch opens



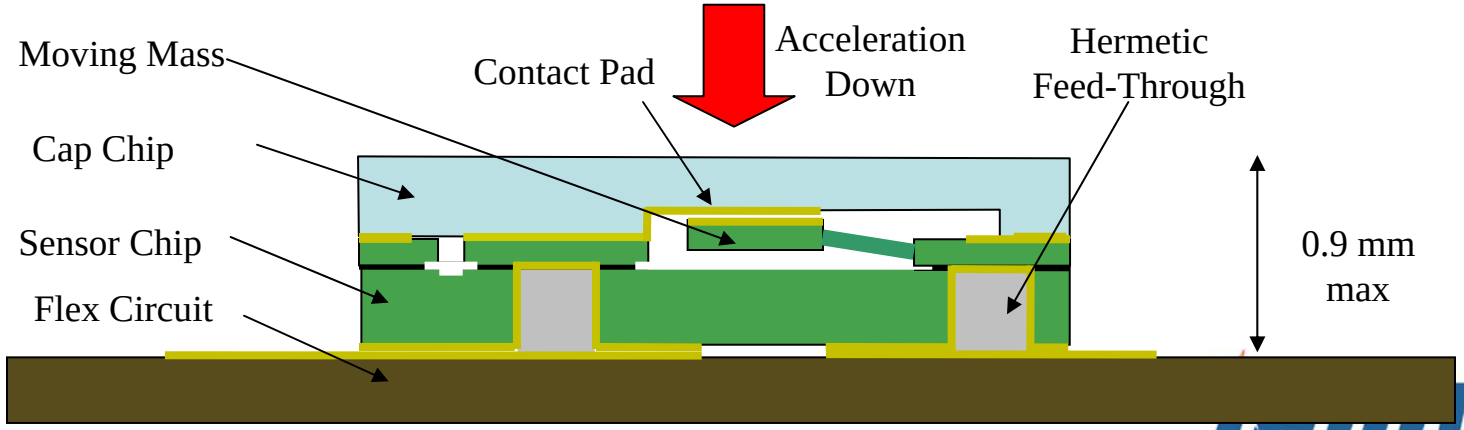
Contact Switch Schematic

Packaging and Signal Routing

Switch Open



Switch Closed



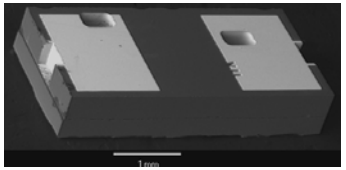
2-Spring Design

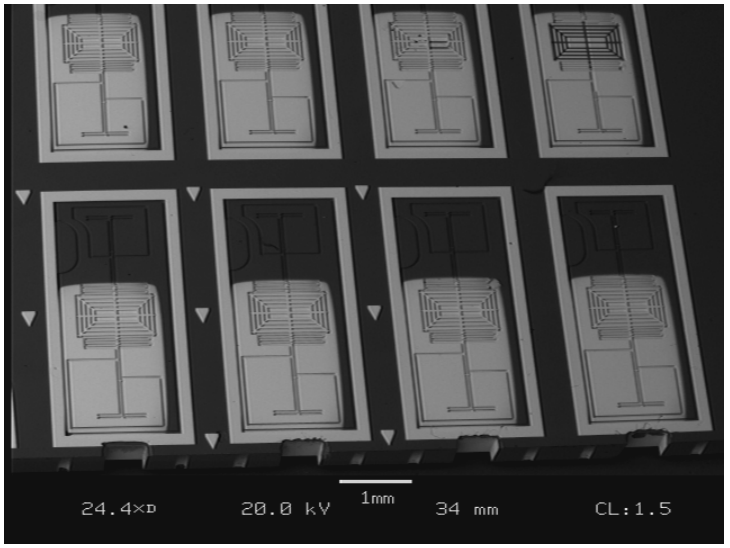


Switch Sealing

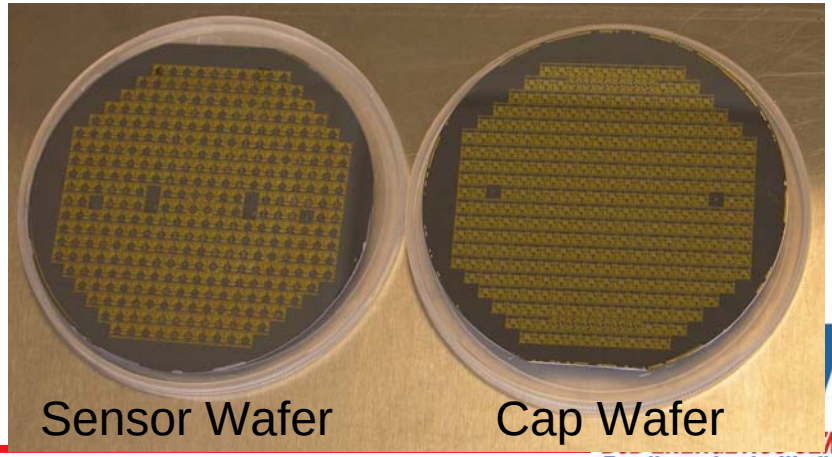
Requires MEMS Chip to Cap Chip Bond

- Option 1:
  - Seal arrays of 12, then sub-dice into individual sensors



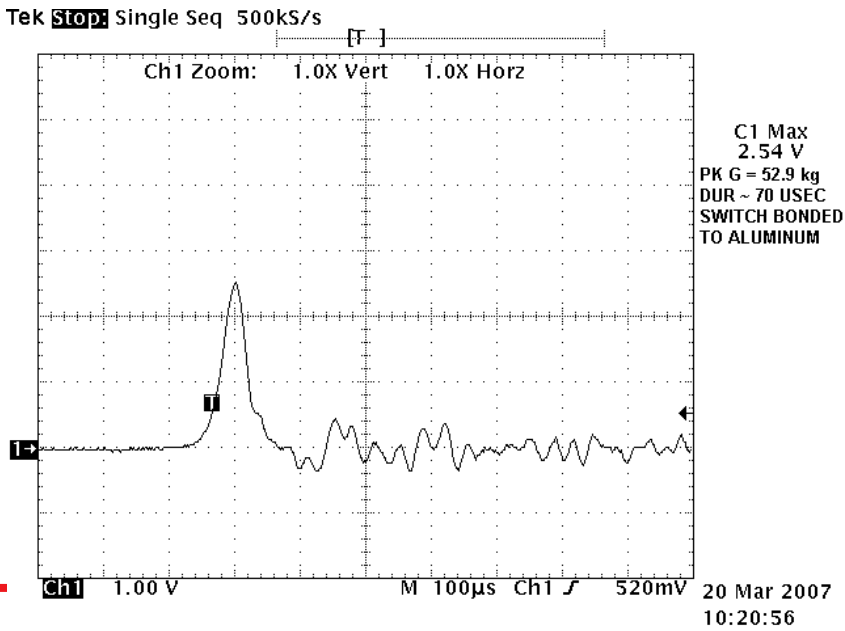


- Option 2:
  - Use wafer bonding to seal over 600 sensors simultaneously, then dice into individual sensors



Contact Switch Status

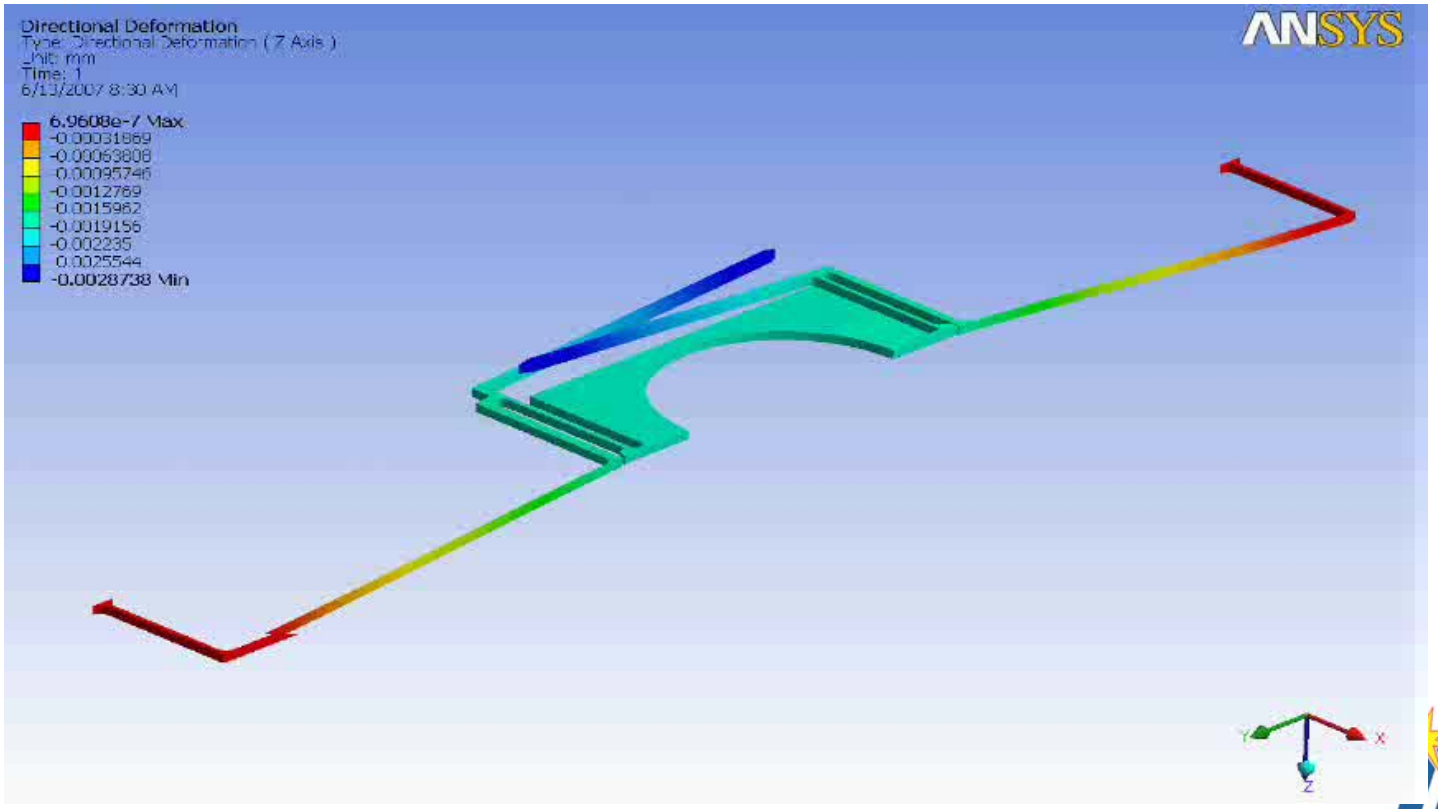
- Switch testing to date:
  - Passed 50,000 g shock, operation successful before and after
  - Contact level approximately 150 g
  - Gun launch successful
- Improvements for next round
  - Switch contacts
  - Wafer level packaging



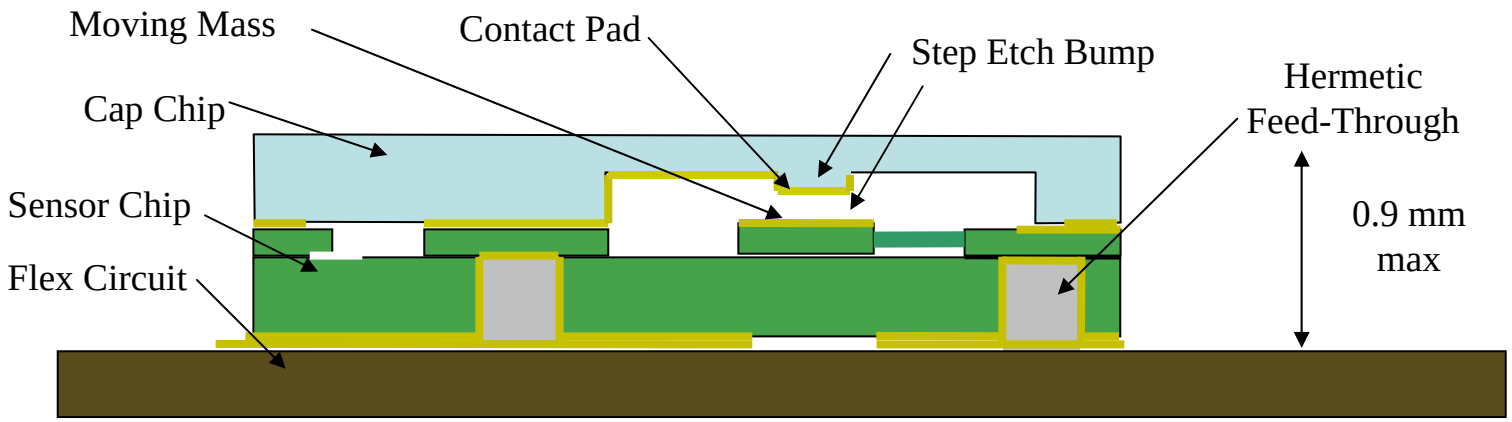
Two Spring Switch

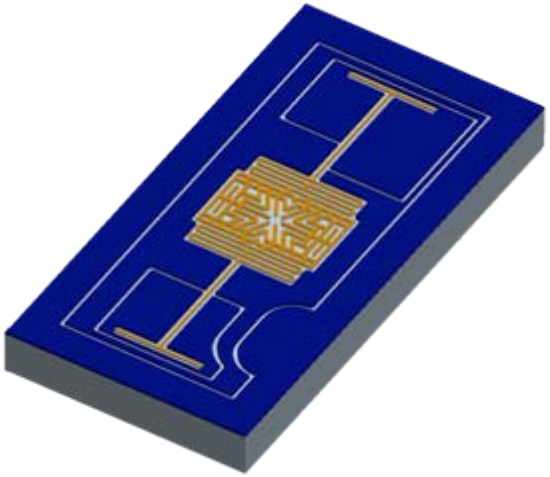
Contact Arm Variation

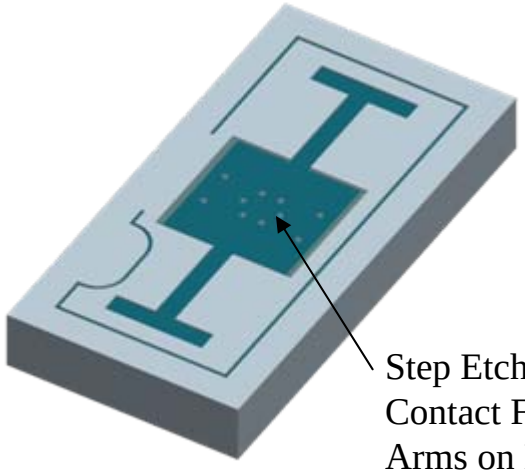
- Contact points move ahead of the mass
  - Increased contact duration
  - Reduced switch bounce



Next Generation Contact Switch





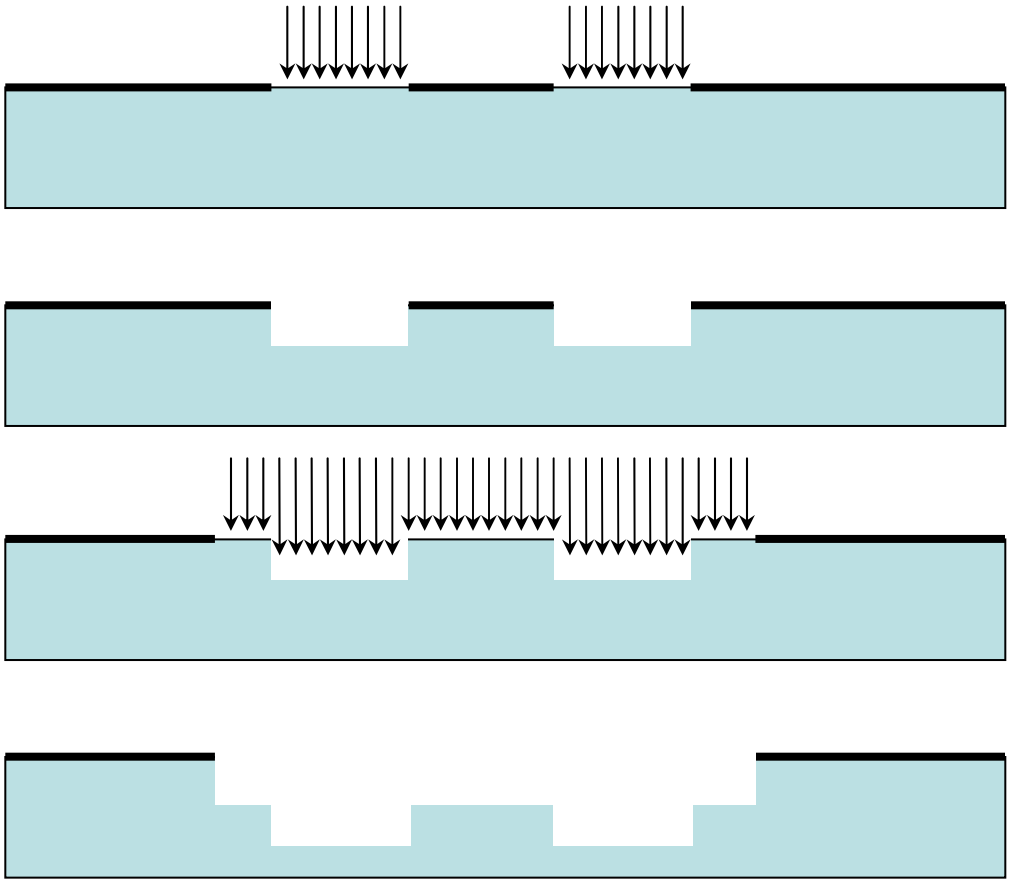


Step Etch Advantages

- Increased contact pressure
- Increased signal duration
- Resistance to residue on contact area
- Reduced squeeze film damping

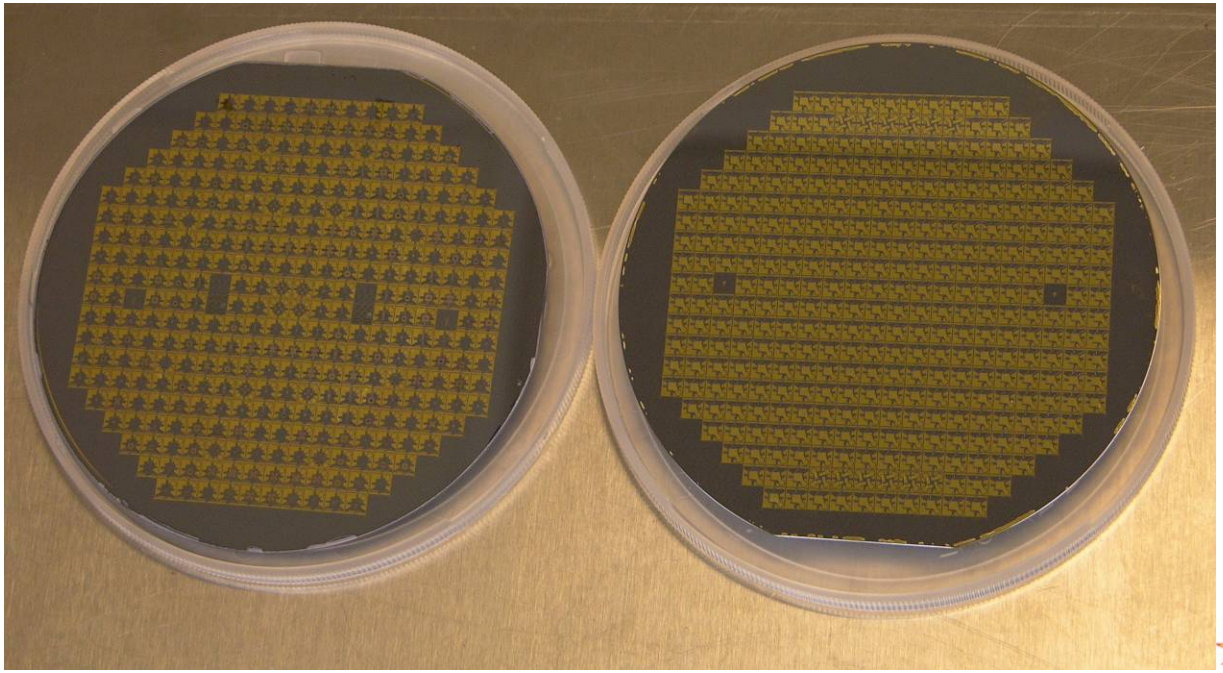
Step Etch Process: Cap Fabrication

Deep Reactive Ion Etching of Silicon



Contact Switch Summary

- Small, surface mount
  - Prototypes are 2 x 4 mm, and 0.8 mm tall
- Hermetically sealed using array level packaging
- Provides a closed switch during the shock event



Sensor wafer (left), and cap wafer (right)

Fuze
Warhead & Fuze Technology

Design and Fabrication of Small-Sized Radar-Radiometer Sensors with a Single Antenna Configuration in W-Band for Sensor-Fuzed Systems



53rd Annual Fuze Conference
May 19 – 21, 2009

Wan-Joo Kim, Myung-Suk Jung,
Won-Young Uhm, Jae-Hyun Choi

Fuze Group, Agency for Defense Development Republic of Korea

국방과학연구소
AGENCY FOR DEFENSE DEVELOPMENT

Contents

- ❖ Why Millimeter Wave for Fuzes ?
- ❖W-Band Radar / Radiometer Fuzing Sensors
- ❖ Experimental Results
- ❖ Summary

Why Millimeter Wave for Fuzes ?

- Advantages of MMW Fuzes
  - Located between microwave and IR, MMW (millimeter wave) can overcome drawbacks of the bands.
  - MMW fuzes can be structurally small in size.
  - If the carrier frequency is high, we can generally get the high space resolution.

Why Millimeter Wave for Fuzes ?

- Passive Radiometer
  - Receive the energy emitted from the targets and backgrounds.
  - Receive the reflected energy of sky radiation by the targets and backgrounds.
  - Contrasts exist between the targets and backgrounds.

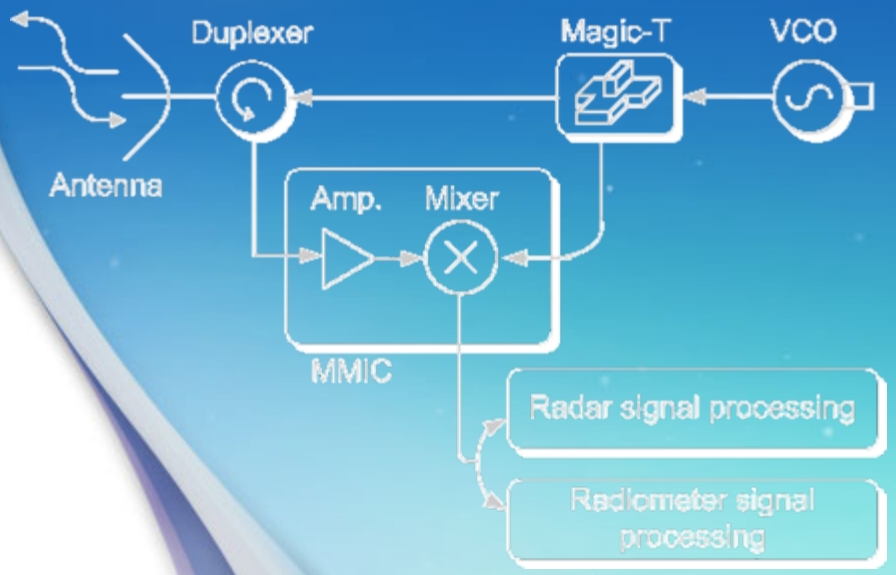
Why Millimeter Wave for Fuzes ?

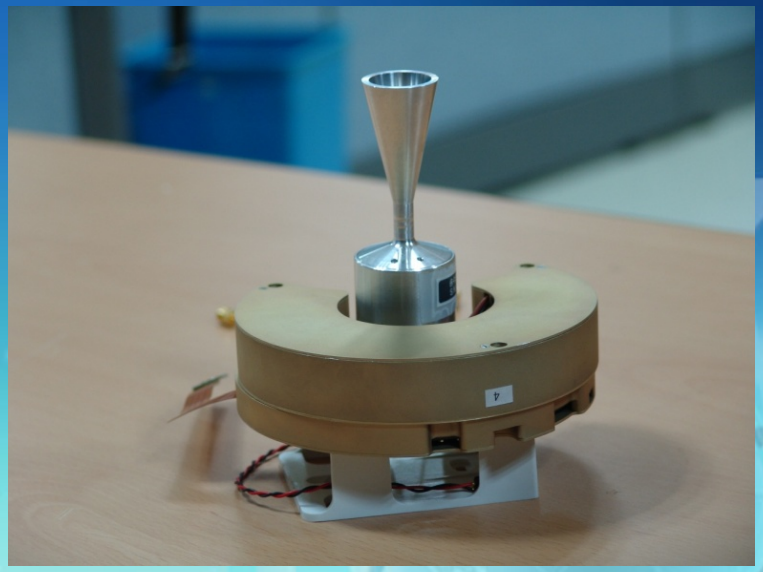
- Active Radar
  - Detect the portion of the transmitted signal scattered from a target in the direction of the receiver.
  - Since the reflectivity of a target is larger than that of the clutter, there exists signal level difference between the target and clutter.

W-Band Radar / Radiometer Fuzing Sensors

- Common Tx / Rx with a single antenna configuration
  - FMCW radar / TP radiometer
  - Simultaneous operation
  - Compact size

W-Band Radar / Radiometer Fuzing Sensors





W-Band Radar / Radiometer Fuzing Sensors

- Front–end & Antenna
  - Pout : 11 dBm
  - Rx Loss : 6.5 dB
  - NF : 10.2 dB
  - Ant. Gain : 23 dB
  - Ant. BW : 12.5°



W-Band Radar / Radiometer Fuzing Sensors

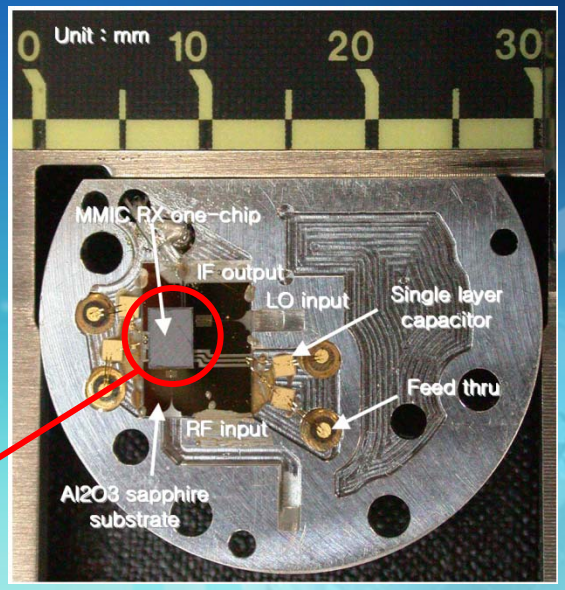
- Duplexer
  - OMT & Polarizer
  - Insertion Loss : < 0.5 dB
  - Isolation : > 30 dB

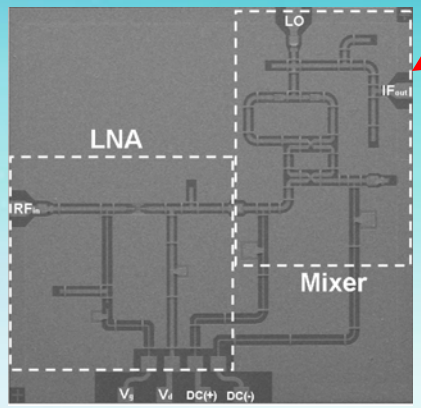




W-Band Radar / Radiometer Fuzing Sensors

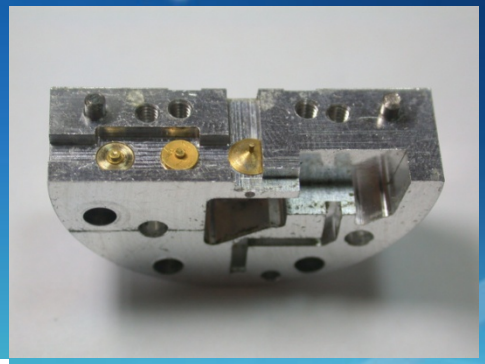
- MMIC Receiver
  - LNA + Mixer
  - LNA NF : 3 dB
  - Total CL : 6.5 dB

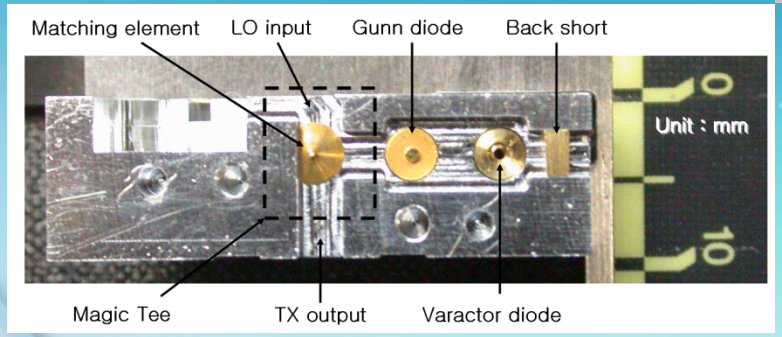




W-Band Radar / Radiometer Fuzing Sensors

- VCO & Magic Tee
  - VCO Pout : 15.5 dBm
  - Sweep BW : 300 MHz

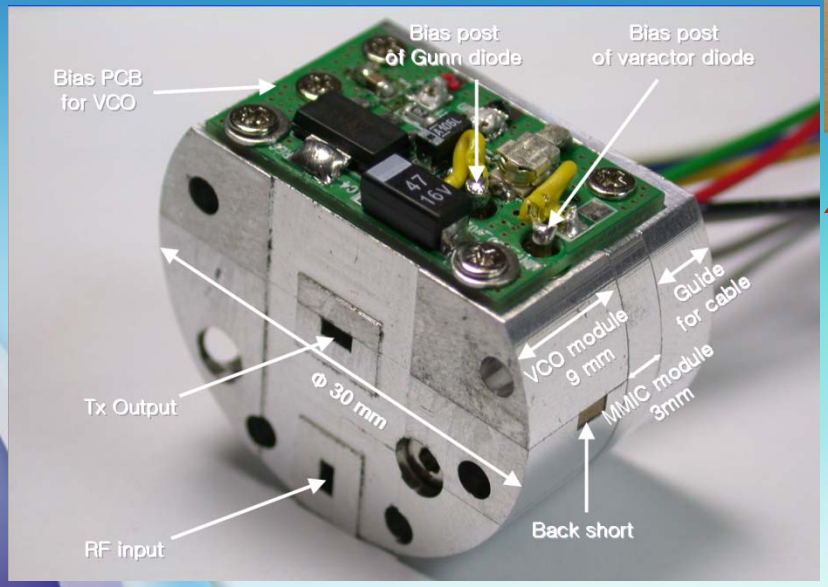




W-Band Radar / Radiometer Fuzing Sensors

- VCO & MMIC Module

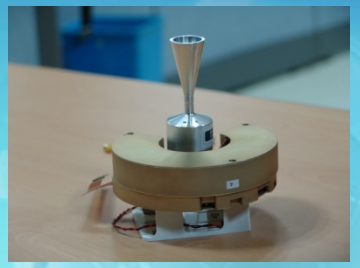




W-Band Radar / Radiometer Fuzing Sensors

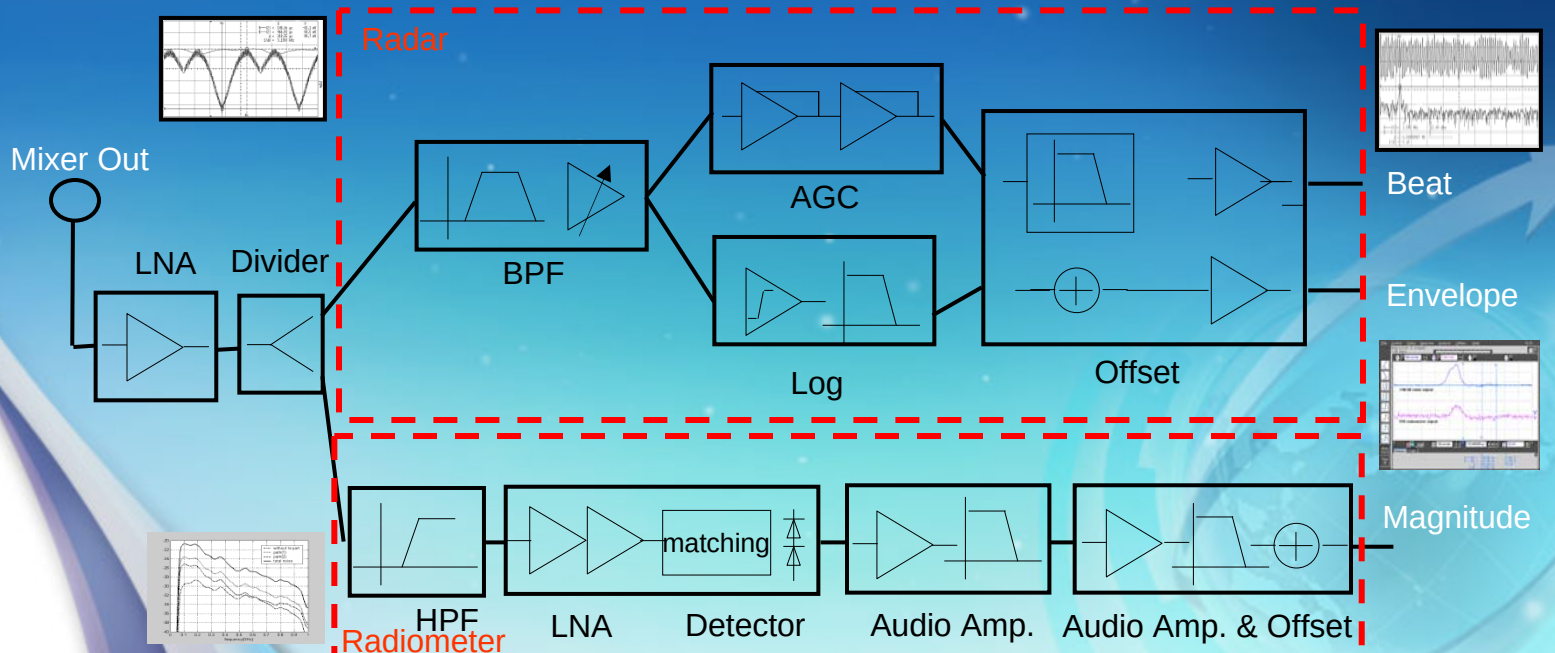
- Radar & Radiometer Signal Processing
  - Radar BW : 2 MHz
  - Radiometer BW : 500 MHz





W-Band Radar / Radiometer Fuzing Sensors

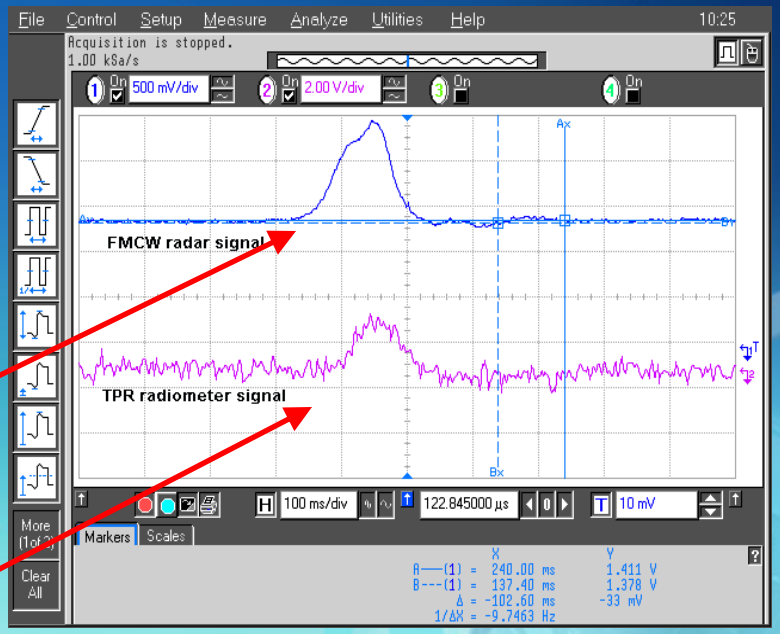
❖ Radar & Radiometer Signal Processing



Experimental Results

❖ Target Detection (1)



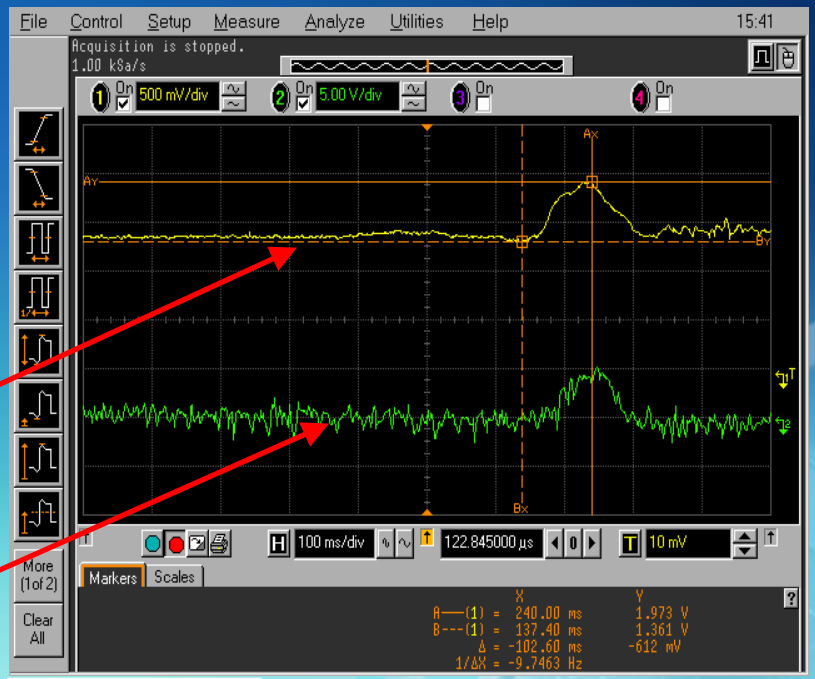


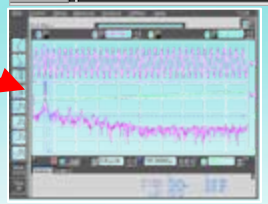
- ❖ Top : radar
- ❖ Bottom : radiometer
- ❖ Range : 25 m

Experimental Results

❖ Target Detection(2)







- ❖ Top : radar
- ❖ Bottom : radiometer
- ❖ Range (FFT) : 60 m

Summary

- W-band radar / radiometer fuzing sensors
- Compact size with MMIC receiver
- High output power because of the low insertion loss of duplexer (OMT & polarizer)
- MMW fuzing sensors will be widely used because of high resolution and small size.



Thank You

Fuze Group, Agency for Defense Development Republic of Korea

US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

Malcolm Baldrige National Quality Award 2007 Award Recipient

XM1158 40mm PROXIMITY FUZE

EXPLOSIVE TRAIN DESIGN

XM 1112 ANLM (Airburst Non-Lethal Munition)

ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER ★ PICATINNY ARSENAL, NJ ★

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

40mm Proximity Fuze Design Team

US Army RDECOM ARDEC Fuze Division
Picatinny Arsenal, NJ

C. Scott Lyon, PE
973-724-3231

Timothy M. Mohan
973-724-5710

Steven E. Stephey
301-394-0768

May 21, 2009

NDIA 53rd Fuze Conference - Orlando

Distribution Statement A: Approved for Public Release; Unlimited Distribution

OUTLINE

- INTRODUCTION
- Airburst Non-Lethal Munition (ANLM) Project Overview
  - Schedule
  - Participating Organizations
- Operational Parameters
- ANLM Sequence of Operation
- Fuze Design Approach
- M550 S&A Background
- Explosive Train Design
  - Initial
  - Current
- Piston Acutator
- Explosive Train Subassembly Testing & Results
- Other Fuze Subassembly Tests
- SUMMARY – QUESTIONS?
- ANLM Demo Functioning Video

ANLM Project Overview

- The XM1112 Airburst Non-Lethal Munitions provides selective non-lethal area denial, crowd dispersion or individual/crowd behavior control capability. The system will provide consistent non-lethal effects & significantly increase range capabilities. Proximity fuze enables airburst delivery of NL payloads throughout operational ranges. It has user settable proximity delay mode for room clearing.

- The Joint Non-Lethal Weapons Directorate (JNLWD) is the executive agent for all NL capabilities within DOD and are the program sponsor. The ANLM is a joint program between the US Army, the lead service, and US Air Force. The US Navy and US Marine Corps have expressed program support.

- The XM1112 ANLM is the Tactical Non-Lethal Munition Increment I Capabilities Development Document material solution that was JROC approved on 14Jul08.

- The XM1112 is presently under PM Soldier Weapons management and executed by US Army, ARDEC. Upon approval of Milestone C the program will be transitioned to PM Close Combat Systems for production.

ANLM Project Overview (cont.)

- **Airburst Non-Lethal Munition (ANLM)**
  - **Type Designation XM1112**
    - **Fuze Type Designation XM1158**
  - **Schedule**
    - **Concept Demo July 2006**
    - **Milestone B March 2009**
    - **Fuze Sub-assembly Testing 2008-09**

    - **Integration Testing 2009-2010**
    - **Qualification Testing 2010-2011**
    - **Joint Fuze Safety Board Cert. 2011**
    - **Milestone C September 2011**

Participating Organizations

JNLWD – Joint Non-Lethal Weapons Directorate
Sponsor

US Army Infantry Center/DCD – Firepower Division
Requirements Generation and User Proponent

Air Force Security Forces Center (AFSFC)
User Proponent

PM-Soldier Weapons
RDT&E Management

PM-Close Combat Systems
Production Management

US Army, ARDEC
Munition Lead and Fuze & Projectile Design

NSWC Dahlgren
Payload Technical Lead

ATK Launch Systems
Payload Design Improvements and Integration Support

HECOE
Human Effects Analysis and Support

SAVIT Corp.
Cartridge Design Improvements, Integration, and Development Hardware Support

Aberdeen Test Center – DTC&AEC / NSWC CRANE
Test & Evaluation

Indiana Ordnance Inc.
Developmental Testing

Kansas State University
Environmental Assessment

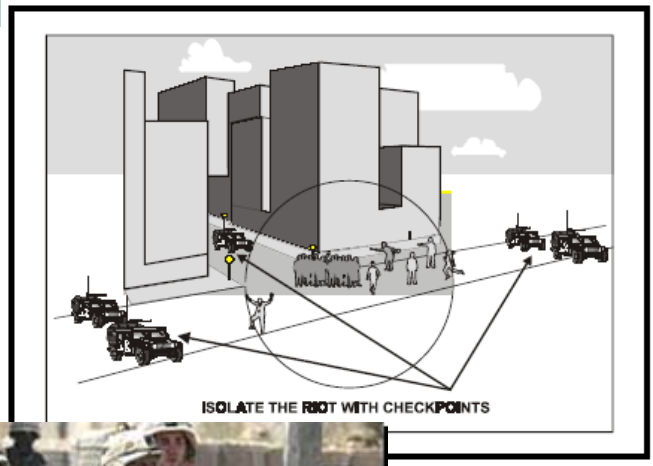
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Operational Parameters



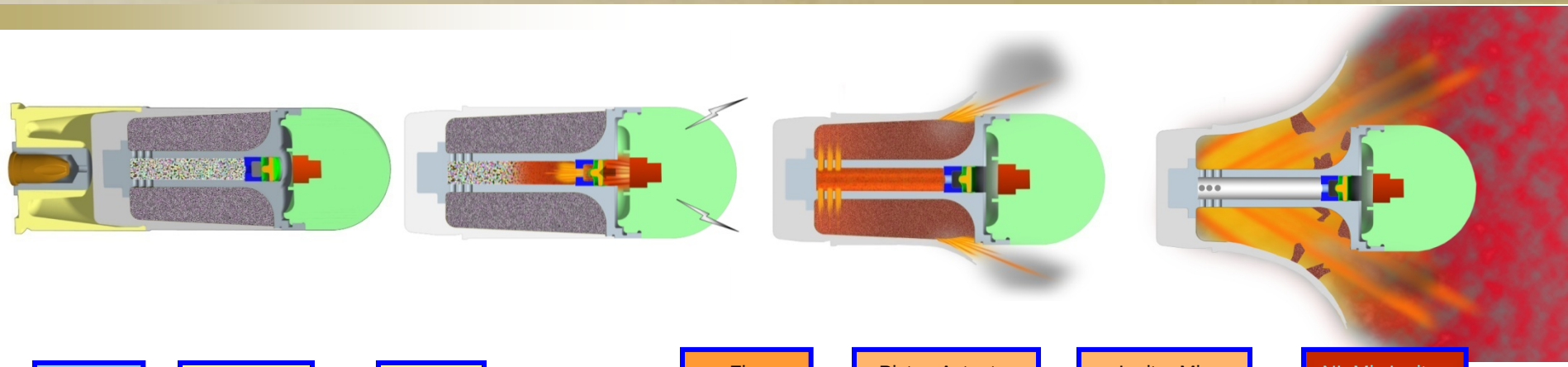
- Operational Environment
  - M203 Ballistic environment
    - Compatible with M79, M320
    - 250 ft/s; 63 rps; 15,500 g's
  - Temperature range: -25°F to +140°F
  - Ballistic Equivalent to M433 cartridge
- Operational Requirements
  - Minimum Engagement Range: 35m(T), 15m(O)
  - Shelf Life: 10yr(T), 20yr(O)
  - Engage targets in open terrain & confined spaces
  - Self Destruct/Self Neutralization

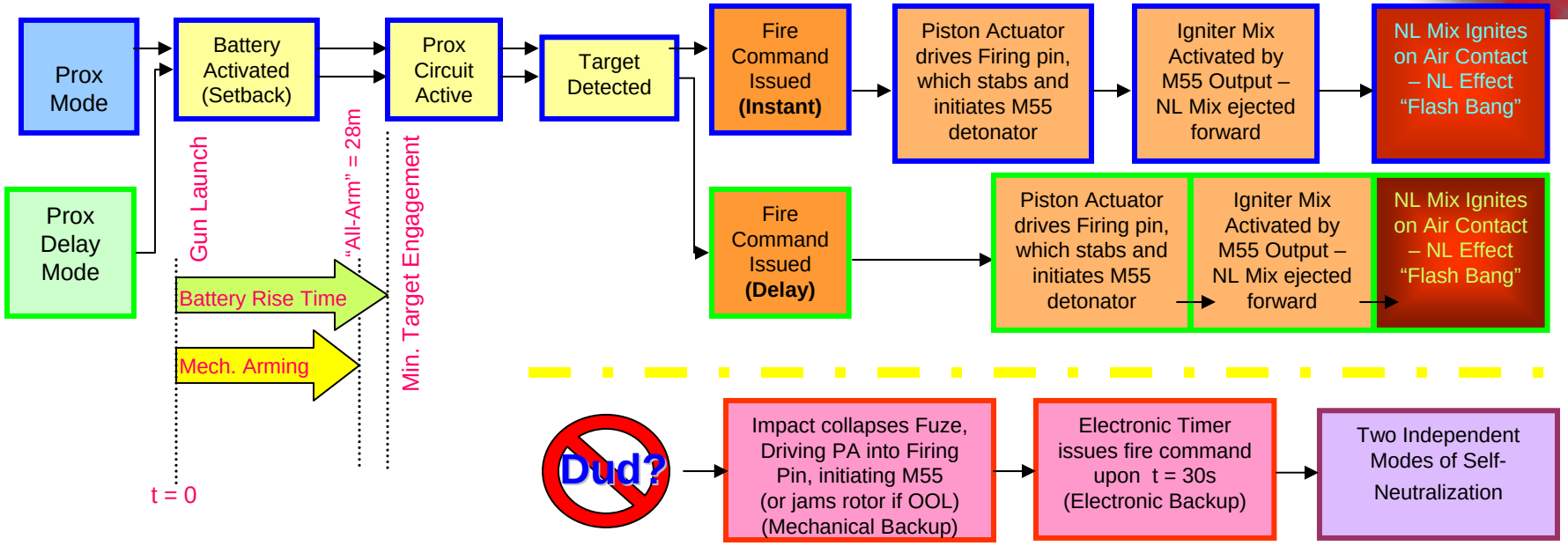




XM1158 – 40mm Proximity Fuze – EXPLOSIVE TRAIN

ANLM SEQUENCE OF OPERATION





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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

FUZE DESIGN APPROACH

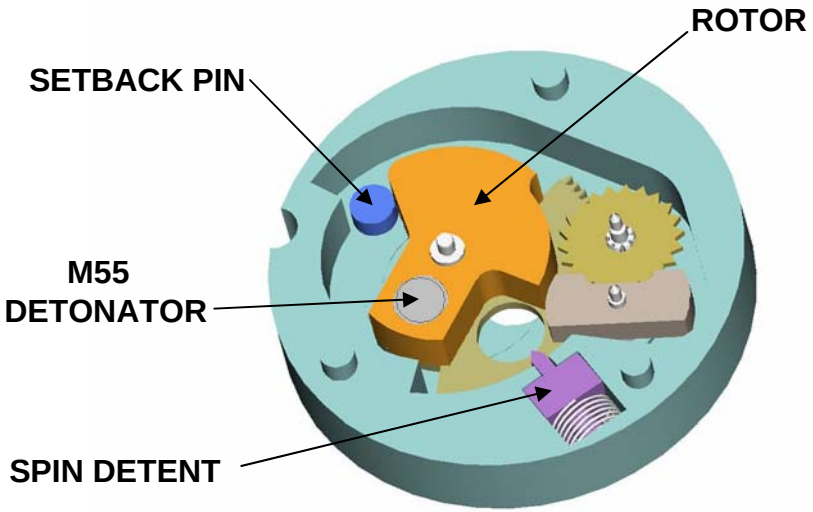
- **Limited Funds Available for Fuze Development**
  - **Emphasis on leveraging existing technologies from other fuzes**
    - **Proximity technology for use in Direct-Fire scenario (EX433 & M734A1)**
    - **Existing mechanical S&A – M550**
    - **Small, fast-activating, reserve-cell battery (EX433)**
- **Utilizes existing mechanical S&A**
  - **Inexpensive & Reliable**
  - **Proven history (>20 million produced)**
- **Piston Actuator Used to Drive Firing Pin**
  - **Initiates M55 Stab Detonator in M550 S&A**
  - **Early design used M100 electric detonator**
- **Transitioned ARDEC Fuze Design to Savit Corp for design refinements**
- **Potential use on other 40mm low velocity cartridges**

M550 FUZE - Background

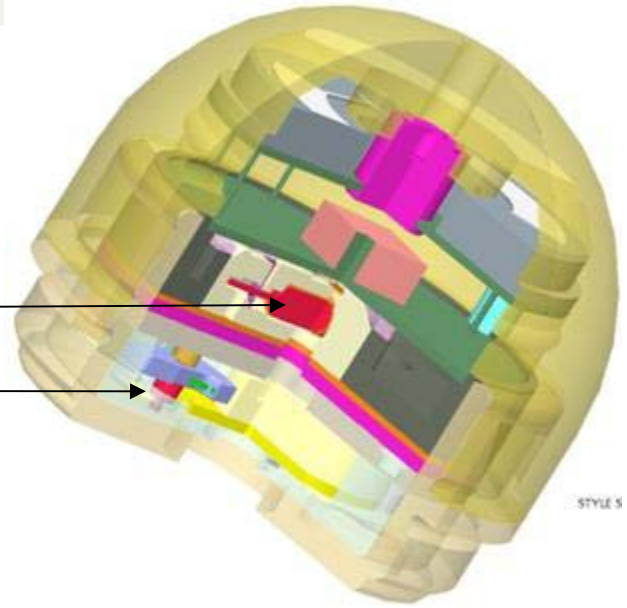
History

- The M550 Fuze was Type-Classified in 1971 for the low velocity (250 ft/sec) M433 High Explosive Dual Purpose application
  - Also used in M918 high velocity Target Practice cartridge
- In Production - Over 20 Million fuzes have been produced
- Two independent safety locks (setback pin & one spin detent)
- Excellent safety record





CONCEPT DEMO EXPLOSIVE TRAIN



9 - Month Concept Demo

"Zero-to-Test Hardware"

in Nine - Months

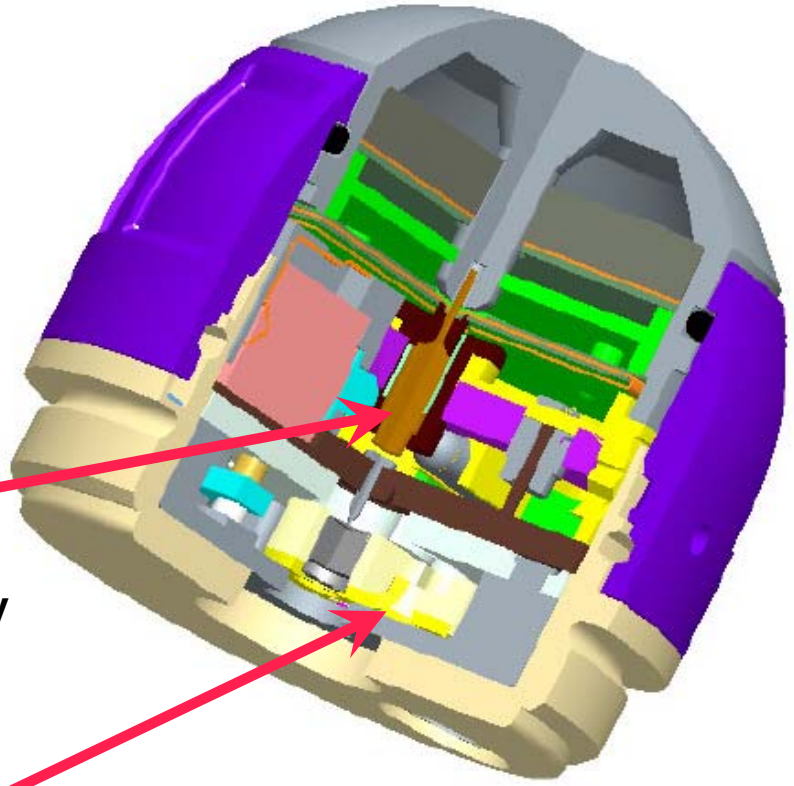
- Initial design used a M100 electric detonator input into the M55 stab detonator
  - M100 positioned 90° "sideways" above M55
    - Used because electric detonators are available, inexpensive, & reliable
    - Utilized MOFA detonator plug & contact clip assembly
  - M100 did not reliably initiated M55
    - Out of line safety barrier plate between M100 & M55 attenuated M100 output

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EXPLOSIVE TRAIN

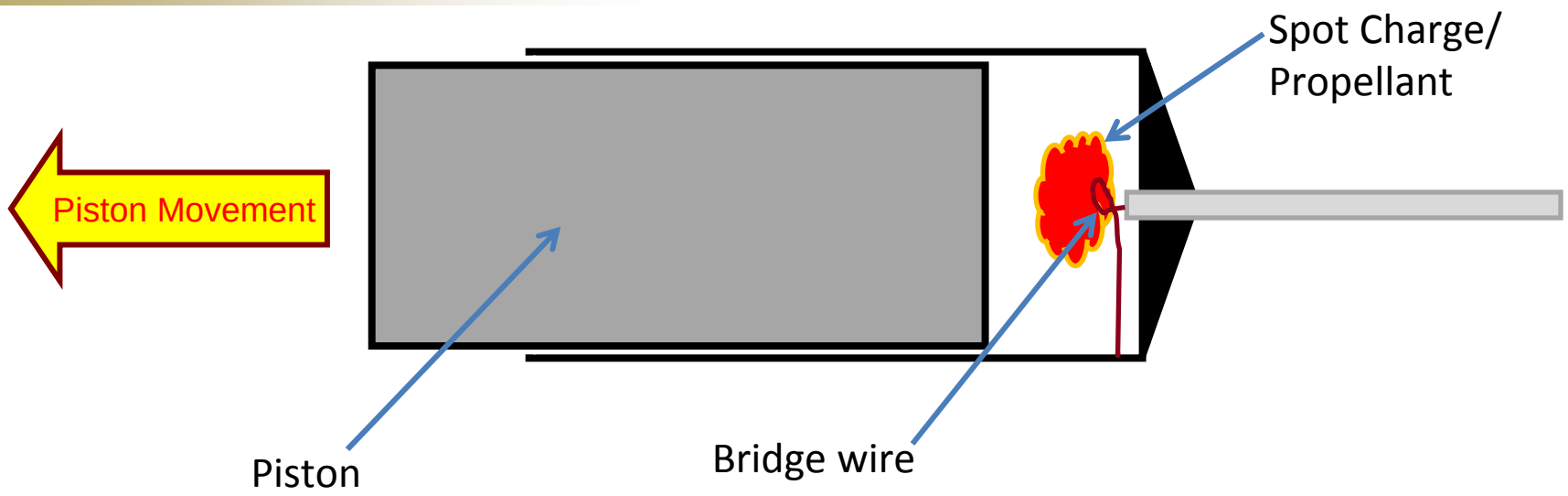
- **ARDEC redesigned explosive train to closely duplicate 40mm M550 fuze**
  - **Duplicated firing pin dimensions**
  - **Piston actuator pushes firing pin into M55**
    - **Positioned on centerline**
    - **Activates on command detonation from proximity circuit**

- **Design Details**
  - **Piston Actuator – Action Mfg**
    - **Directly connects to circuit card assembly using pin and socket connection**
    - **Piston has attached firing pin**
    - **Used in PD backup mode**
  - **M550 Safe & Arm Device - Amtec Corp.**
    - **Used on current 40mm HE & practice rounds**
    - **Contains the two independent MIL-STD-1316 compliant safety locks**



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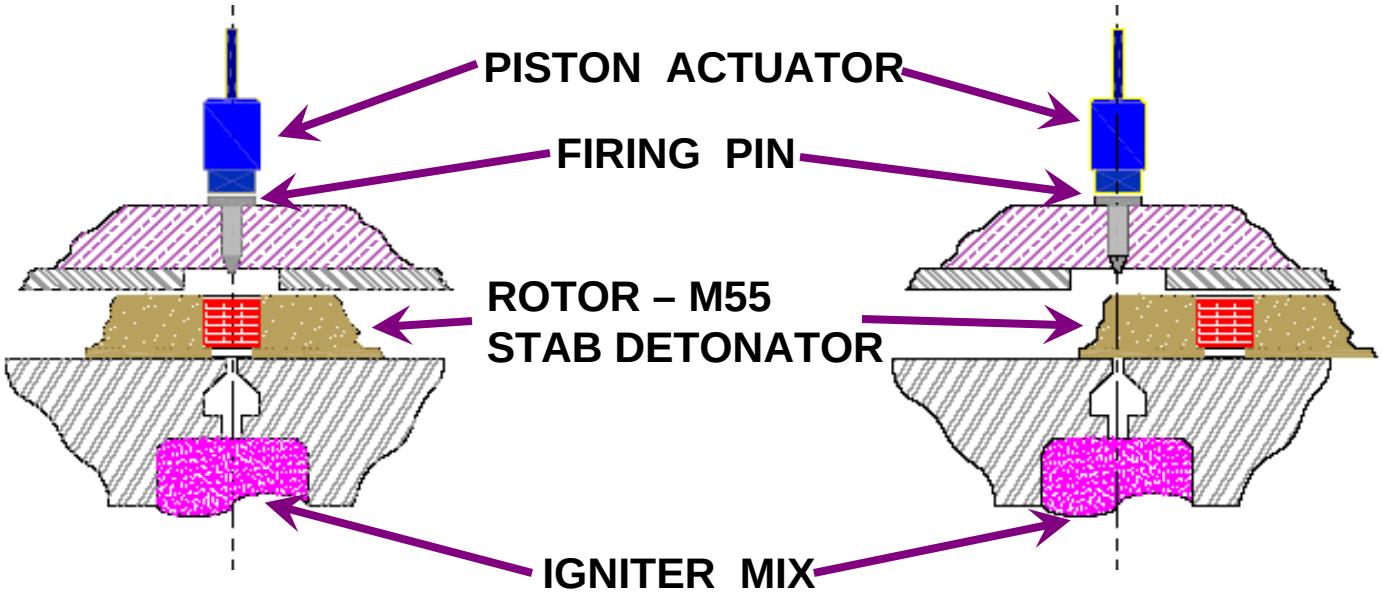
EXPLOSIVE TRAIN



Piston Actuator – Action Mfg

- Approximately 50 lbs force & 0.090” displacement
- ~5mg Spot Charge
- Bridgewire Resistance = 1.5 ± .5 ohms
- All Fire Energy = 22 microfarad capacitor at 2.5 volts
  = 687.5 erg = .06875 joules

FUZE EXPLOSIVE TRAIN TESTING

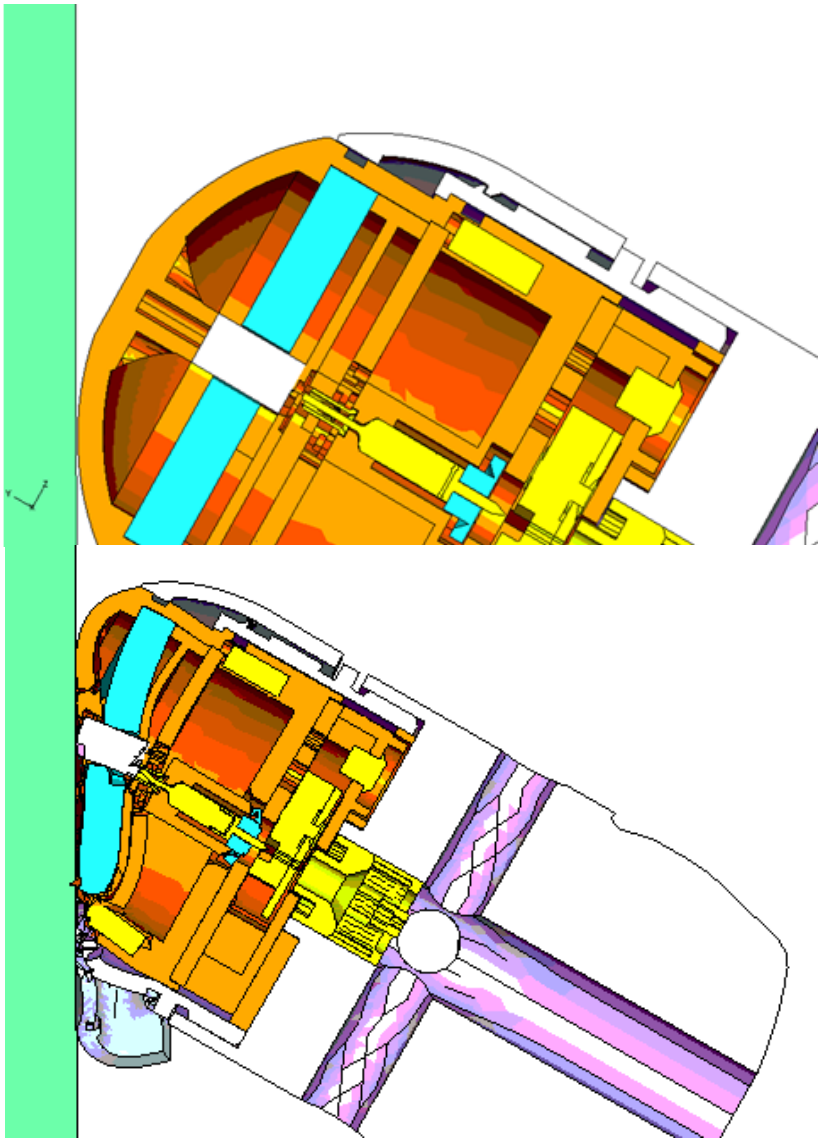


- **Explosive Train Subassembly Testing**

  - **Explosive Train Subassembly Tests – Successful Jan-May 2009**
    - **"In-Line" Explosive Component Output – MIL-STD-331, Test D4**
    - **"Out-of-Line" Explosive Component Safety – MIL-STD-331, Test D1**
    - **Progressive Arming Test – planned 3Q FY09 - MIL-STD-331, Test D8**

FUZE EXPLOSIVE TRAIN TESTING

- **Explosive Train Subassembly Testing (cont'd)**
  - **Point Detonation Backup Subassembly Tests**
    - **Head-on Impact Angle Test– Successful March 2009**
    - **Angle of Attack Impact Test– planned June 2009**
      - **Utilizing decision matrix to determine 50% functioning point**
      - **Use samples at operating temperature extremes**



FUZE SUBASSEMBLY TESTS

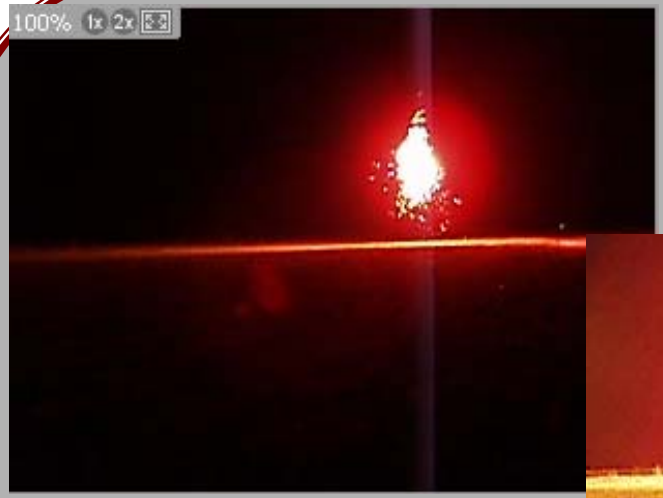
- **Non Explosive Train Subassembly Testing**
  - **Battery Activation Mechanism Subassembly Test**
    - **Mechanism w/o battery – Successful July 2008**
      - **Drop Test non-activation per MIL-STD-331, Test A4.1**
      - **Ballistic Test activation – M203 Mann Barrel into foam soft catch**
    - **Actual battery – planned June 2009**
      - **Repeat drop and ballistic tests**
  - **Mode Select Subassembly Test/ Electronics Survivability - Planned July 2009**
    - **Ballistic Test – M203 Mann Barrel into foam soft catch**
- **Non-Lethal Warhead Testing**
  - **Fuze explosive train successfully ignited warhead energetic material**

SUMMARY

- **SUMMARY**
  - **Explosive Train Tested Successfully**
  - **Created Command Initiated Stab Detonator**
    - **Maintains current explosive train**
    - **Utilizes proven mechanical S&A**

- **SHOW VIDEO – ANLM FUNTIONING – Concept Demo July 2006**

END OF PRESENTATION







QUESTIONS?

40mm Proximity Fuze Design Team
US Army RDECOM ARDEC Fuze Division

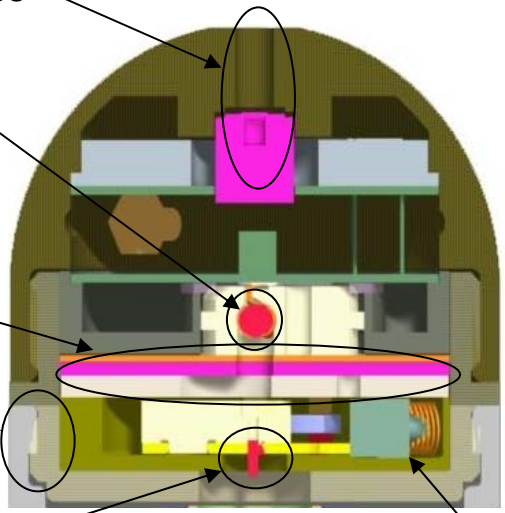
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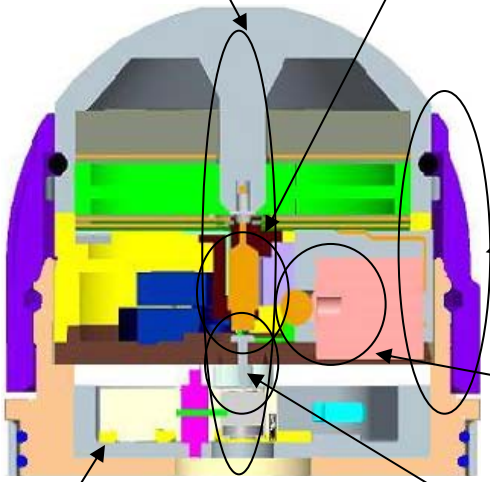
Steven E. Stephey
301-394-0768

EXPLOSIVE TRAIN – Initial vs. Current

Initial Design



Current Design



ADVANCED MUNITION POWER SOURCE TECHNOLOGY

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ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER PICATINNY ARSENAL, NJ

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Carlos M. Pereira U.S. Army ARDEC, RDAR-MEF-S
carlos.m.pereira1@us.army.mil; 973-896-5909

Hai-Long Nguyen U.S. Army ARDEC, RDAR-MEF-S
hailong.nguyen@us.army.mil; 973-724-1543

Charles McMullan U.S. Army ARDEC, RDAR-MEF-S
chuck.mcmullan@us.army.mil; 973-724-2755

Jahangir Rastegar PhD Omnitek Partners, LLC
j_rastegar@omnitekpartners.com; 631-665-4008

Taylan Alanson PhD U.S. Army ARDEC, RDAR-MEF-S
taylan.alanson@us.army.mil; 973-724-2389

MUNITION POWER SOURCE NEEDs

- High G survivability from Gun Launch (5 kGs – 140 kGs)
- 20 Year Shelf Life
- Extreme Temperature performance
  - - 40 F^{o} to +145F^{o} Operating Temperature
  - - 65F^{o} to +165F^{o} Storage Temperatures
- High Power and Energy Density
- High reliability
- Cost effective







Develop affordable munition power supply technologies with increased power and energy densities, that can satisfy tactical munition requirements.

Initial research conducted under several SBIR programs phase I and II

1.Phase I & II SBIR " Innovative Conformal Power Sources for Advanced Munitions"
2.Phase I & II SBIR "Innovative Optical Based Wireless Communications Technology for Smart Munitions
3.Phase I & II SBIR "Miniature Power Supplies"
4.Phase I & II SBIR "Inertial Ignition Systems"
5.Phase I & II SBIR "Miniature Electrical Ignition Systems"
6.Phase I & II SBIR "Low Cost Improved Thermal Batteries"
7.Phase I & II SBIR "Thin Film Thermal Batteries".

Technologies demonstration and validation

- Supported under ARDEC ATO titled "Fuze and Power for Advanced Munitions"

Additional research development to:

- Optimize power systems volumetric efficiency
- Heat management optimization for thermal reserve power systems
- Scalability across all munition calibers
- Miniaturization, reliability and identification of materials for low cost
- Transitions to acquisition programs

Objective

- Bring a systems approach to the management of power requirements throughout the mission profile of smart and guided munitions across all caliber ranges.
- Develop technologies that free up lethality volume, by reducing the size of power sources
- Reduce munitions power to a single battery or eliminate battery altogether in some applications.

Approach

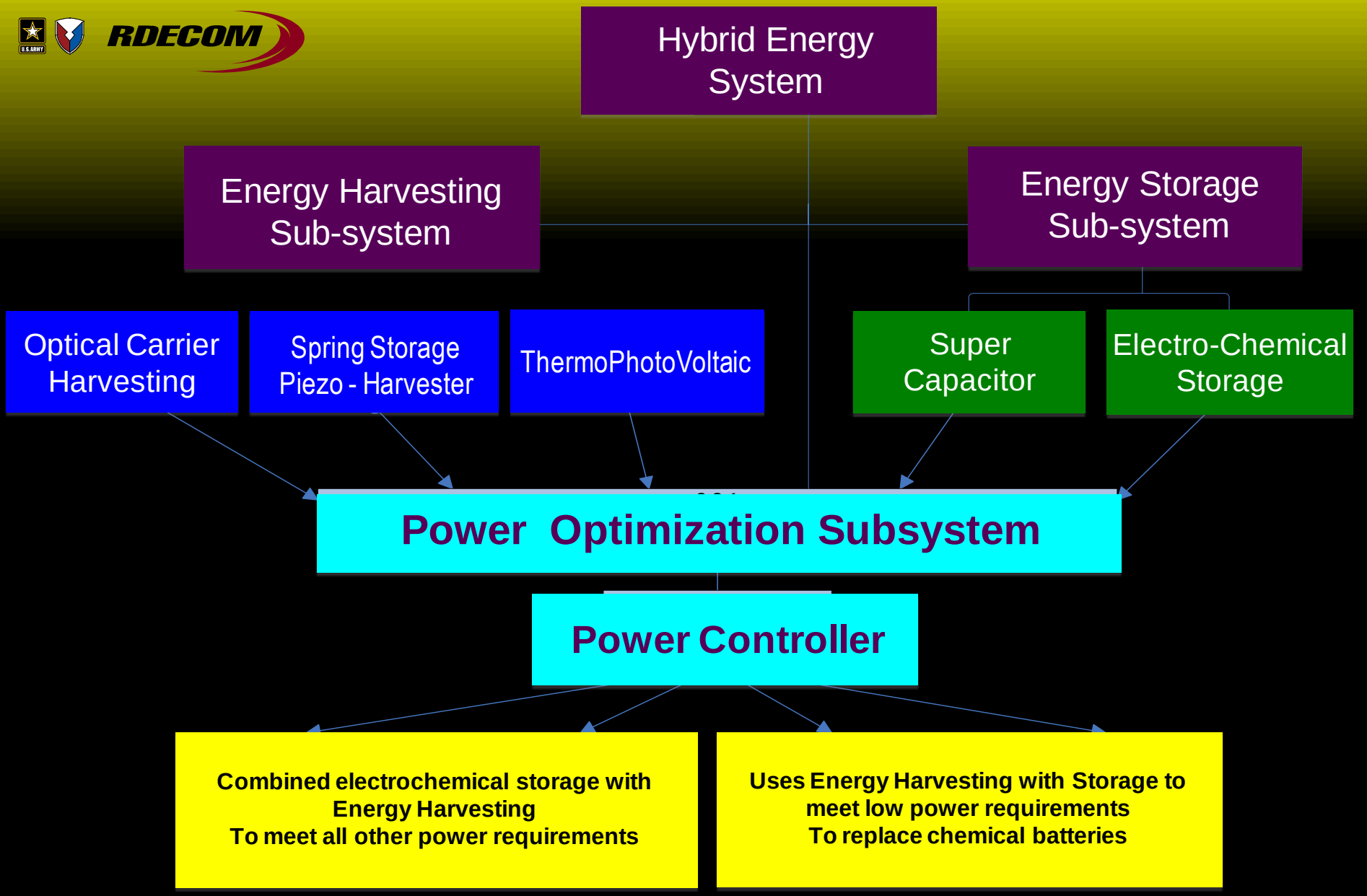
- Harvest energy from the vibrational environment of munitions systems
- Optimize the conversion of energy, store in a capacitor medium
- Combine harvested/stored energy with optimized electrochemical stored energy

Payoff for the Army

- Improve reliability, reduce cost, improve safety, temperature performance and producibility.
- Improve scalability of power systems across all munition caliber ranges.

HYBRID ENERGY SYSTEMS FOR GUN FIRED MUNITIONS

RDECOM

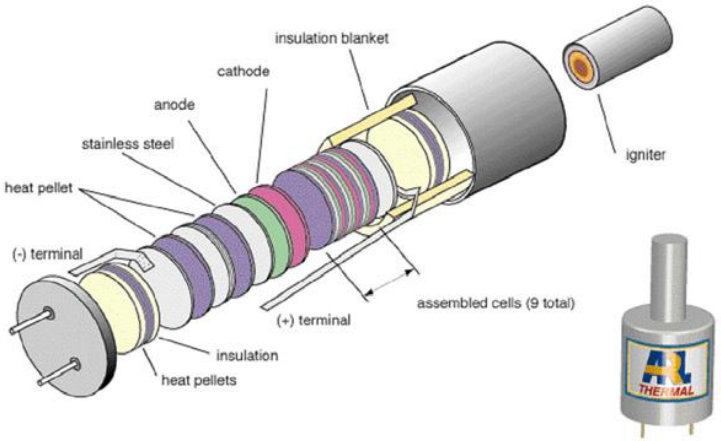


Fast Rise Time Thermal Battery:

- Fast rise time electrochemistry not readily available
  - *Issues with OSHA & EPA regulations*
- Conventional components are thick and brittle
  - *Produced as pressed pellets*
  - *Limited geometry- volume not optimized*
  - *Extra mass to make handling easier – Slows down heat transfer*
- Materials are costly to manufacture
  - *Expensive production equipment & operating costs*
  - *Labor intensive*
- Must survive military environments:
  - *High G-forces from gun launch*
  - *High spin rate (~250-300 rps)*
  - *Minimum 20 year shelf life*
  - *Temperature range of -65 deg F to 160 deg F.*
- Need viable heat source for fast rise time electrochemistry

INERTIAL IGNITERS FOR THERMAL BATTERIES

- Initialize thermal battery
- Inertial activation is preferred
  - No preflight power required
  - Safety mechanism to make go/no-go decision to activate thermal battery
  - Main downfall – size, especially for smaller batteries
  - Significant room for improvement
- Difficult to define requirements up front
  - Systematic process for requirements definition absent
  - Wide variety of munition launch accelerations
- Generate a design which is flexible
  - mass/spring combinations
  - setback / setforward
  - variety of shapes and alternate configuration
- Low G / high G designs



INERTIAL IGNITERS FOR THERMAL BATTERIES (con't)

Objective

Significantly reduce the volume of the inertial igniters to make them suitable for small thermal batteries applications.

- Develop inertial igniters suitable for low to very high-G munitions applications.
- Develop inertial igniters that allow easy integration into all thermal battery designs.

Approach

Development of novel miniature mechanical devices that respond to input impulse with the desired time delay to differentiate firing acceleration profile from accidental events.

- Development of novel single and multi-stage mechanical delay mechanisms that allow for very high delay times in a very small volumes.
- Development of detailed dynamics models, their validation through realistic testing, and optimization of the developed designs.

Payoff for the Army

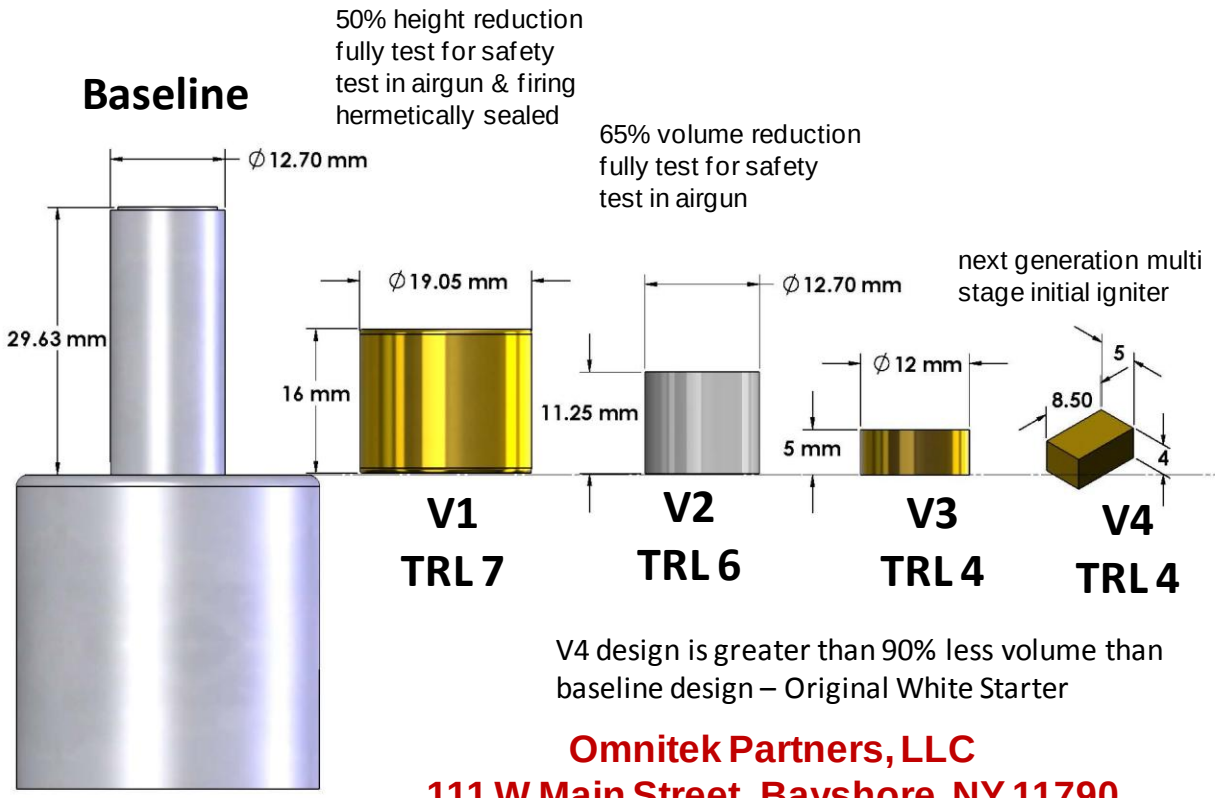
Make inertial igniters available for small thermal batteries to power munitions electronics across all munitions caliber ranges

- Improve reliability, reduce cost, improve safety.

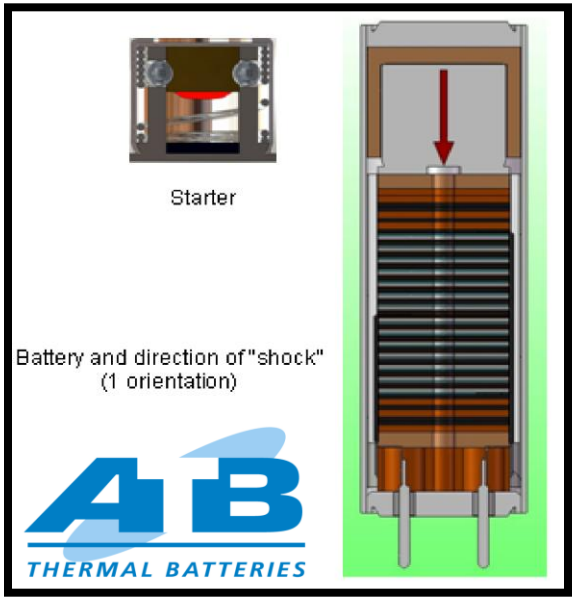
INERTIAL IGNITER for THERMAL BATTERIES (con't)

Thermal Battery Improvements : Miniature Igniter

- Highly miniaturized thermal batteries will require a novel ignition method.
- Various iterations each in different phases.



V4 design is greater than 90% less volume than baseline design – Original White Starter



- Improved integration & cost effective
- Simpler manufacturing process
- Increase industrial base
- Increased battery energy density
- Flexible packaging & manufacturing

Omnitek Partners, LLC
111 W Main Street, Bayshore, NY 11790

INERTIAL IGNITER FOR THERMAL BATTERY (con't)
SUMMARY

Families of miniature inertial igniters are under development as part of SBIR Phase II projects with * Omnitek Partners, LLC and are being mature through ATO

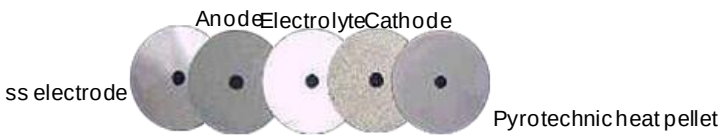
- Two generations of igniters have been prototyped and tested for safety (no-fire conditions) and for all-fire ignition in air guns.
- Two generation of igniters have been integrated into thermal batteries and and tested in air-guns (spin and no-spin tests), and one series as integrated into thermal batteries has been tested in an artillery round (fired at YPG on 08/05/2008)
- Currently teaming and collaborating with Advanced Thermal Batteries
- and Omnitek Partners to develop an improved thermal battery.
- Current collaborations with ATB and Omnitek Partners has resulted in integrated improved thermal battery at TRL 6.
- Scheduled to transition to PM and Acquisition Program

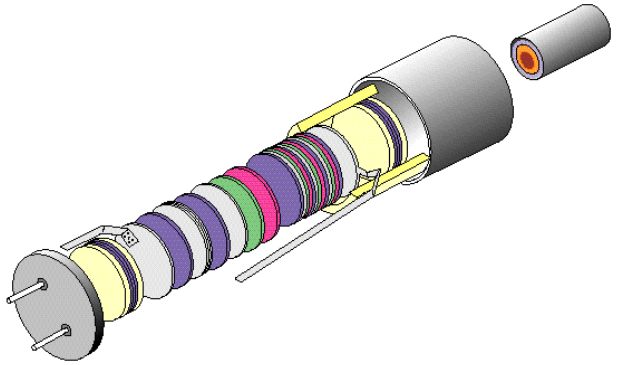
*** DATA RIGHTS: DFARS 252.227-7018 SBIR Data Rights During 5 yrs. can disclose only to support contractors under a nondisclosure agreement; no mfgrg. or buying, only in-house analysis, testing, planning. After 5 yrs. it then becomes unlimited rights, per (1)(vii) of 252.227-7018. Note: 5 yrs data rights can be extended by subsequent government contracts.**

Thermal Battery Improvements

- Achieved 30% increase in runtime by implementing an improved heat management:
  - Extra heat end heat pellets
  - Improved insulation material
  - Sidewall heating
- Investigated runtime improvements utilizing metallic gas getters
- Demonstrated in flight test at YPG on 08/05/08









SPRING STORAGE PIEZO ENERGY HARVESTING

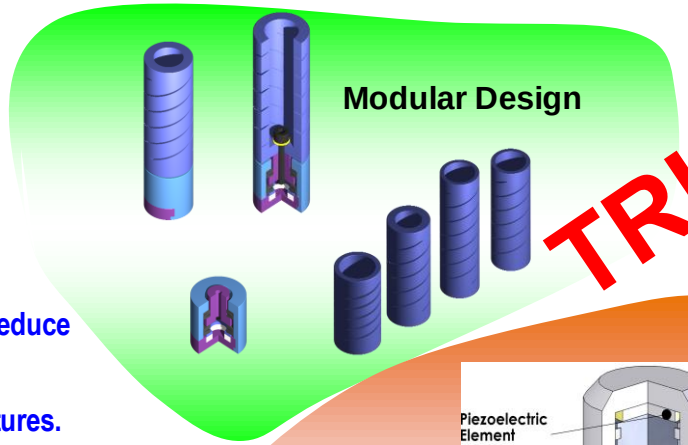
Advantages of Using Piezoelectric-Based Energy Harvesting Power Sources in Munitions

- Safety (no initial power).
- Very long shelf life.
- Relatively small.
- Can replace the onboard battery or reduce size of battery
- Operates in a wide range of temperatures.
- May be integrated into the structure of munitions.
- The level of output voltage provides information about the state of the munitions and can be used as secondary means for fuzing safety and munitions operation.

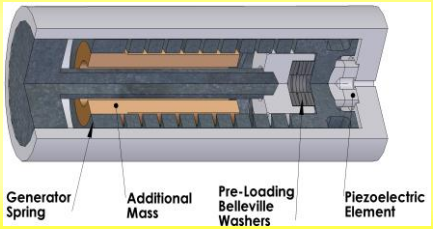
Advantage of Using Spring Storage

For a 1.8 preloading factor, and since only 1/3 of mechanical energy in piezo is electrical energy, the energy converted by the resonating unit is up to (1.8 X 6250 X 3 / 12.5) = 2700 times higher

Axial Piezoelectric Generators



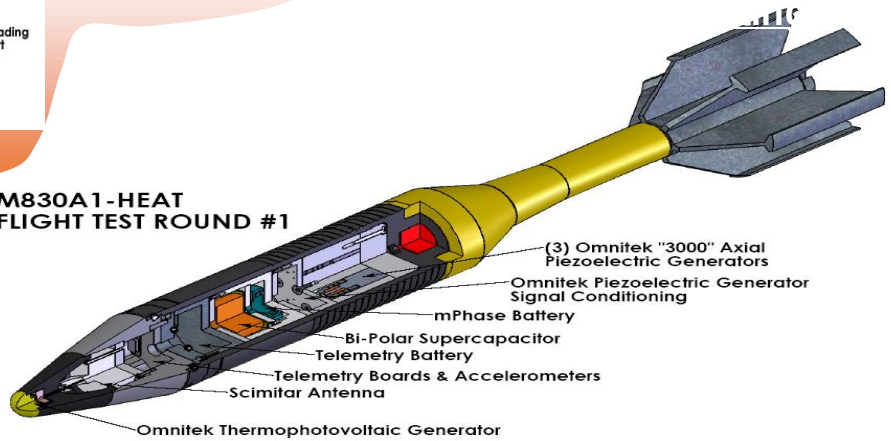
Lateral Piezoelectric Generator



Sources of Energy for Onboard Power Generation

- Firing acceleration.
- Spinning during the flight.
- Drag induced vibration.
- Flow induced heating of leading surfaces during supersonic flight.
- Stored mechanical (potential) energy.

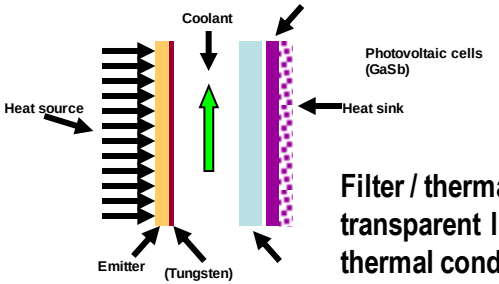
Flight Test 09/25/07



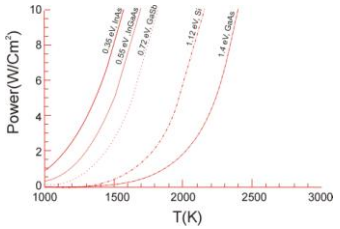
POC:
Carlos M. Pereira U.S. Army – ARDEC
Advanced Precision Concepts Branch Chief
carlos.m.pereira1@us.army.mil;
Desk – 973-724-1542
(Cell) 973-896-5909

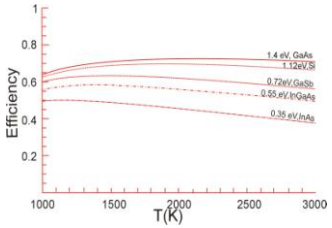
THERMOPHOTOVOLTAIC (TPV) POWER GENERATION FOR SUPERSONIC MUNITIONS

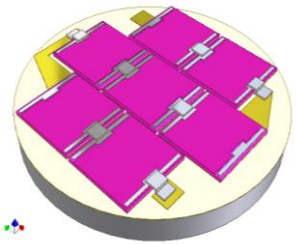
Thermophotovoltaic Materials Based Power Generation – Basic Elements

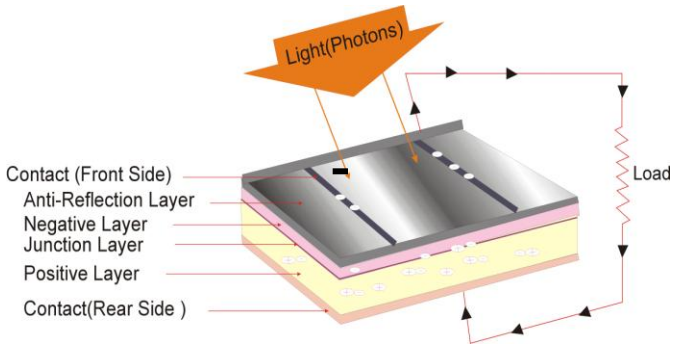


Filter / thermal insulation (a transparent layer with low thermal conductivity, e.g., LiF)

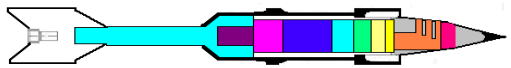








JX Crystals Inc - 3.2 V GaSb IR Circuit - 1 cm x 1 cm

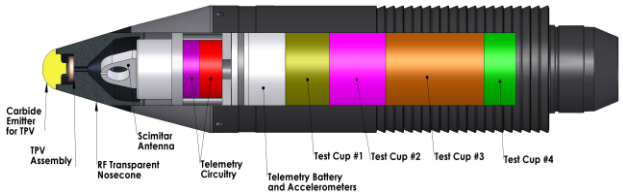




Advantages

- Safety (no initial power).
- Very long shelf life.
- Relatively small.
- Reduces the total onboard battery and/or capacitor volume.
- Can be integrated conformably into the munitions structure.

Flight Test Summer, 2007





POC:
Carlos M. Pereira U.S. Army – ARDEC
Advanced Precision Concepts Branch Chief
carlos.m.pereira1@us.army.mil;
Desk – 973-724-1542
(Cell) 973-896-5909

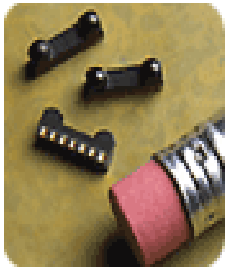
OPTICAL WIRELESS DATA & POWER TRANSFER

Optical Wireless Communications for Munitions

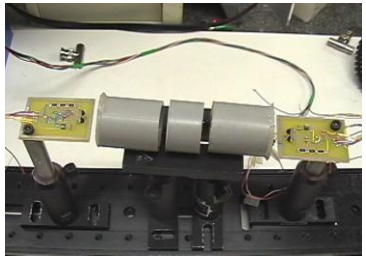
- Potting material utilized as wireless transmission medium (or free space)
- NO Fiber Optics! – optical communication system
- Could be implemented in two ways:
  - Fuze Setter – transfer data (4-16Mb/s) and power preflight (1J less than 0.1s)
  - Wireless communication bus within munition (board to board)
- Demonstrated ½ watt power transmission per cell
- Multiple cells combined for desired power characteristics
- Patented use of “guided” and free space optical communication network in munitions

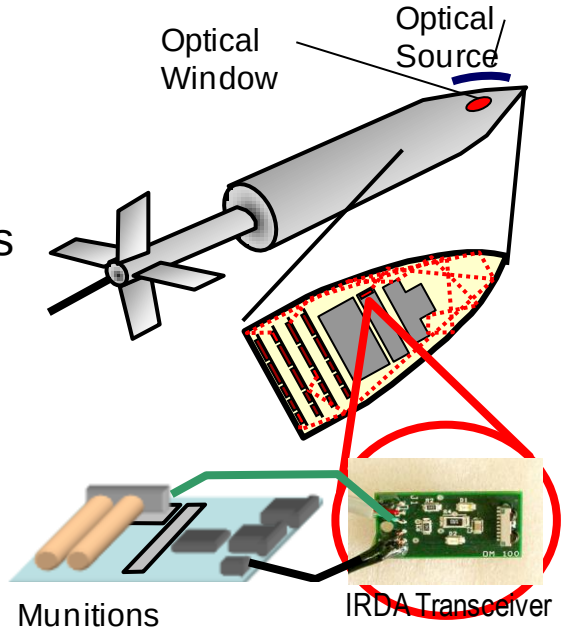
Advantages over wire based systems

- Immune to electromagnetic interference
- Inherently high G tolerant
- Extremely low cost, commercially available components
- Compact and light weight, and low power
- Potential to eliminate umbilical cord or board to board connections



The Smallest IrDA Transceiver

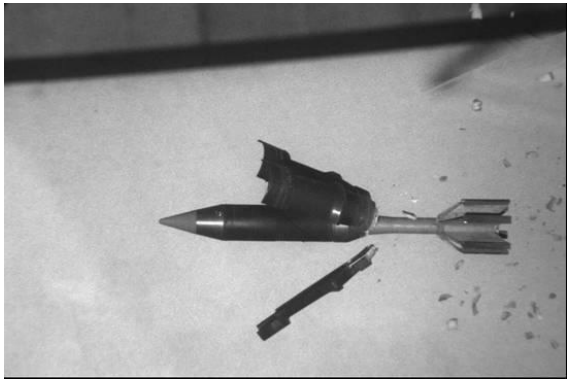




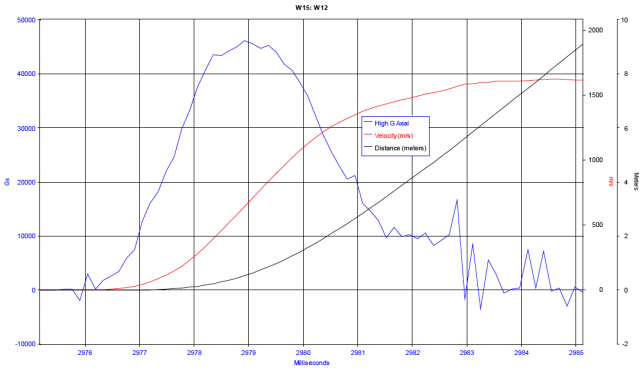
HYBRID ENERGY SYSTEMS SUMMARY

Energy Harvesting technologies are under development as part of SBIR Phase II projects with * Omnitek Partners, LLC and are being mature through ATO

- Built & tested various types of energy harvesters, several types of designs to be mounted axially and radially for flight tests to demonstrate energy harvesting in tri-axial configuration
- First time HES components subjected to gun launched operational environment
- First time converted energy using piezoelectric harvester at over 30% efficiency
- Validated model
- Piezoelectric generators survived 50K G's of setback and produced power to meet ATO objectives
- Excellent quality TM data obtained from flight tests
- Achieved TRL 7



M830A1 tank round upon gun launch



Typical Acceleration Plot for M830A1

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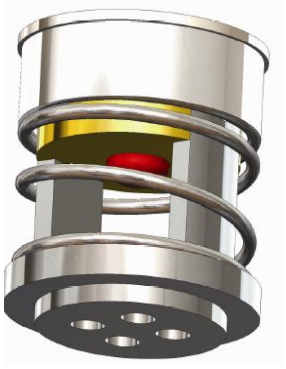
*** Gov't Patent Pending**

BACK UP

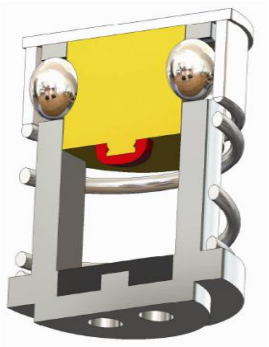
Omnitek inertial igniter and its operation



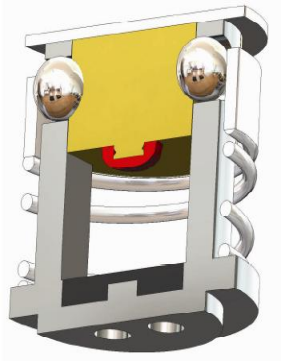
Fully assembled



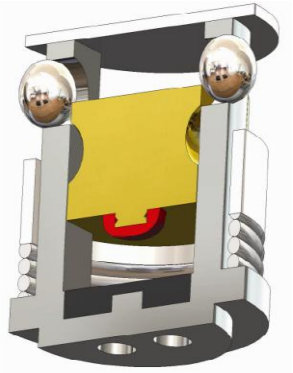
Outer casing removed



At rest (striker locked)



Partial (no-fire) actuation



Full (all-fire) actuation (striker released)



Primer based or two part pyrotechnic ignition available

MINIATURE INERTIAL IGNITION SYSTEMS FOR THERMAL BATTERIES

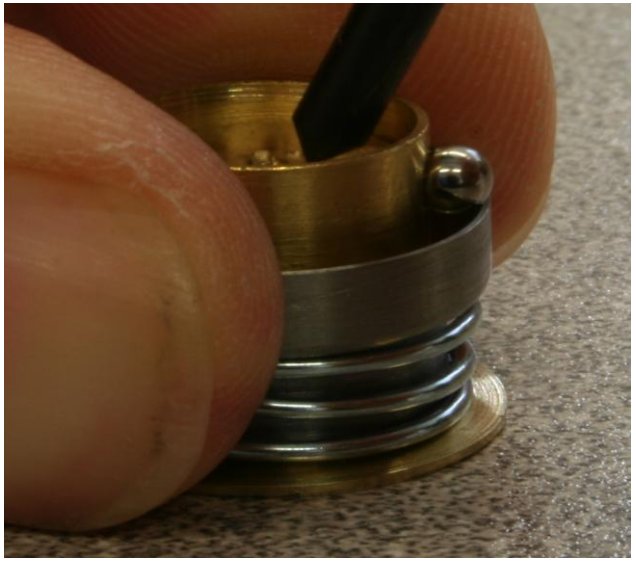


At rest

Operation of the Omnitek "V1" inertial igniter
(Outer casing removed)



Partial actuation



Striker released

SPRING STORAGE PIEZO ENERGY HARVESTING

$E_{mechanical} = 1 Joule = 1 \frac{w}{\sec}$

$E_{electrical} = 1\text{J} * 0.33 = 330\ mjoules$

Power in WATTS is the rate at which energy is used.
and the amount of energy used is measured in JOULES.
Then,
Joules = watts x seconds, therefore watts = joules/seconds.

Then,

$P(watts) = \frac{E}{Time}$

And,

$P(watts) = \frac{(1J)*(0.33)}{0.1\sec} = 3.3 watts$

At V=5 volts; P=3.3watt; $I = \frac{P}{V}$

Then,

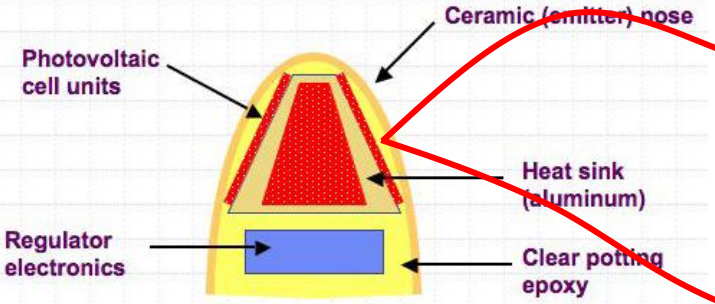
$I = \frac{3.3}{5}$; $I = 66$ ma (milliamperes)

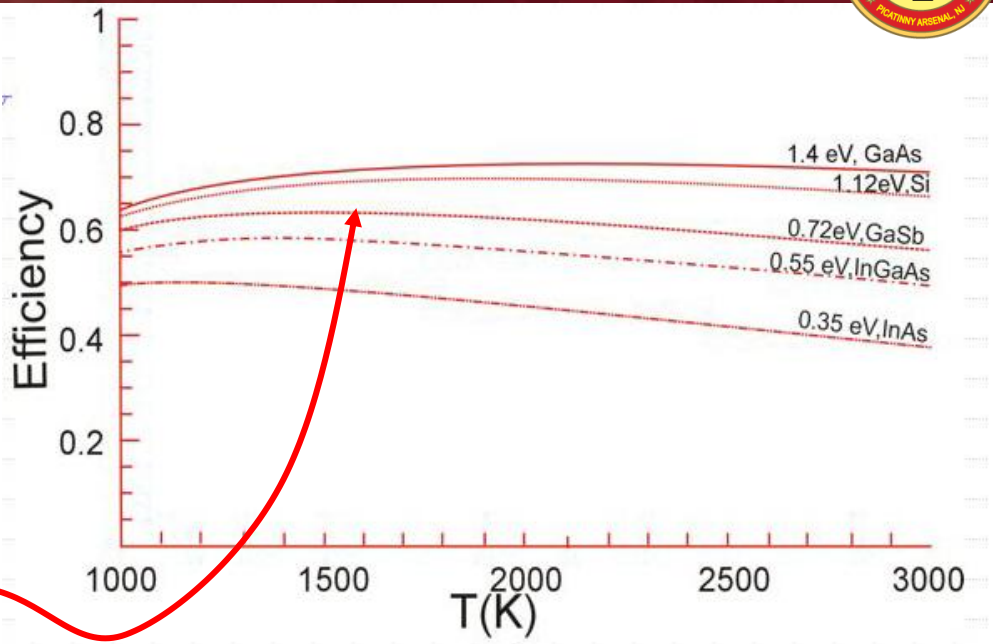
- The harvesters are designed as continuous oscillation harvesters coupled to a staked piezo
- Various designs mounted in both axial as well as lateral directions
- Design in flight round stores 1 joule and it is expected to have a 33% efficiency. It is tuned to about 1.2 KHz.
- Depending on the round vibration range, it may produce more or less than 1 joule.
- The axial harvesters are expected to produce at least 1 Joule
- Since this is the first time we are firing these harvesters in a flight round, we will be learning the profile of the vibrational information by means of onboard sensors.

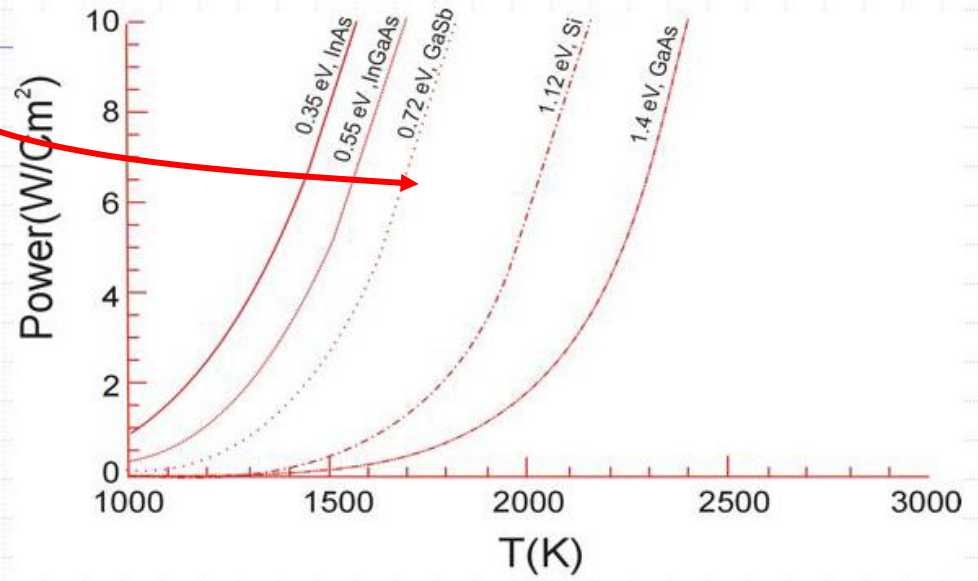
Carlos M. Pereira
x1542

THERMOPHOTOVOLTAIC (TPV)

Thermophotovoltaic Power Generator Integration into the Nose of a Projectile







Hazards of inappropriate fuzing design
or

An accident waiting to happen

-Inappropriate design

-Poor workmanship

-Inappropriate stockpile management

”Limited media coverage”



13:th of September 2003

What happened?



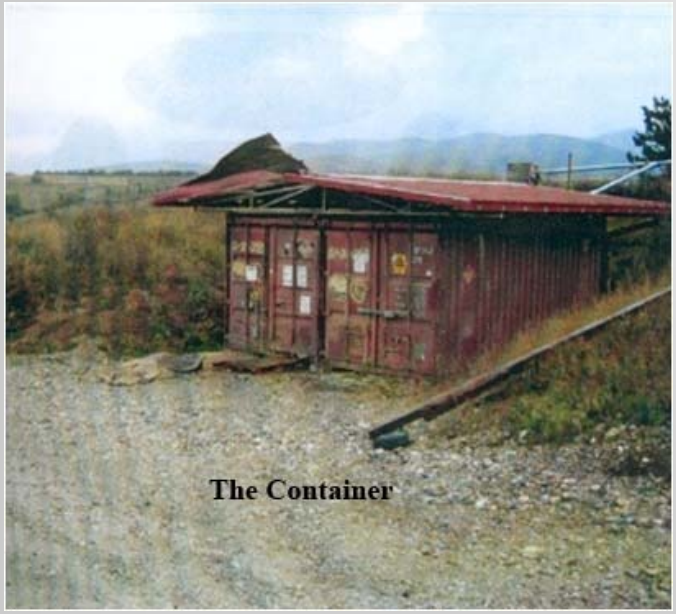
What happened?



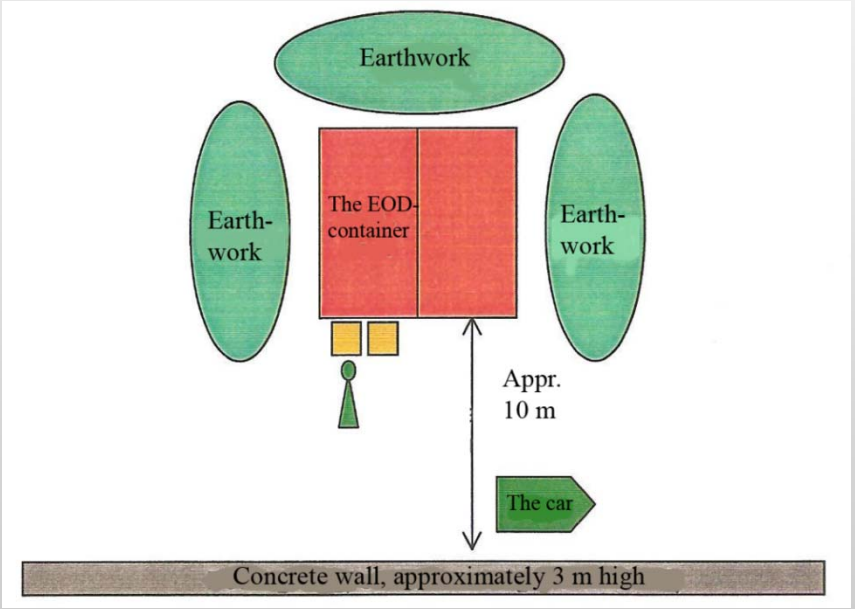
Fragmentation parts from the warhead!?

The Scene of the Accident (II)

Photo of the Scene



Sketch of the Scene



The Anti Tank Hand Grenade m/79

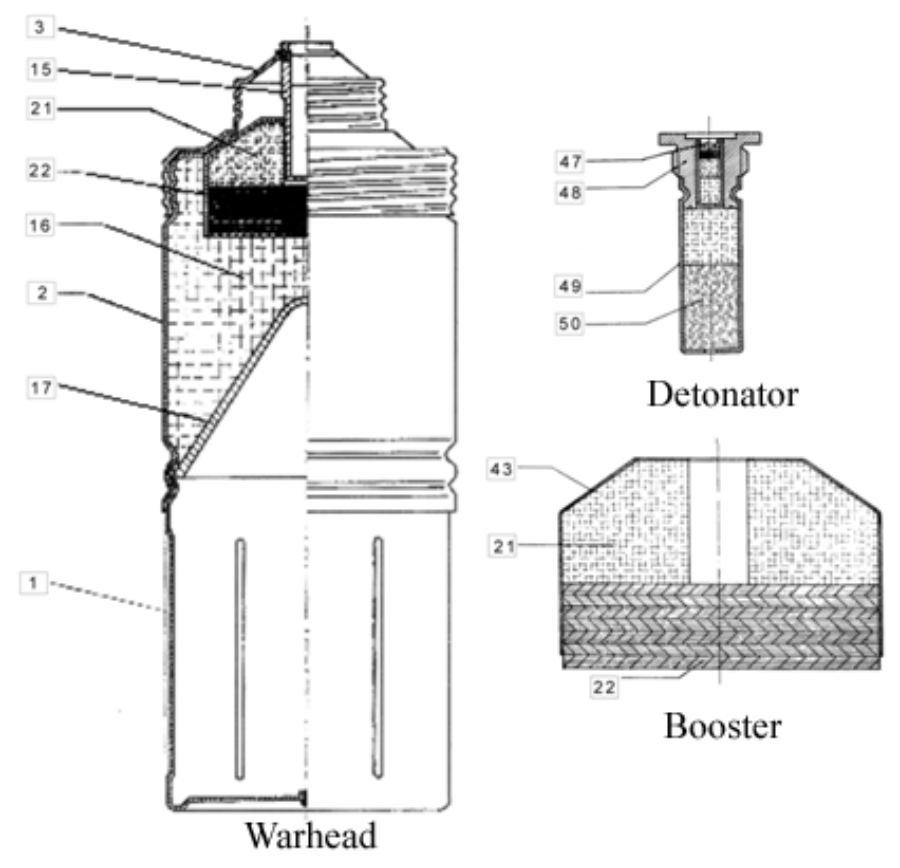
Ammunition Data



- Type: Hand Grenade Antitank
- Type of fuze: Quick / Point detonating
- Main output: Penetration 220 mm
- Additional output: Fragmentation
- Effective fragmentation distance: 20 meter
- Danger area: 70 meter
- Throwing distance: 25 m
- Arming distance: 0 m
- Length: -
- Diameter: -
- Colour: Green or black
- Weight: 1.1 kg



Constituents in the Warhead

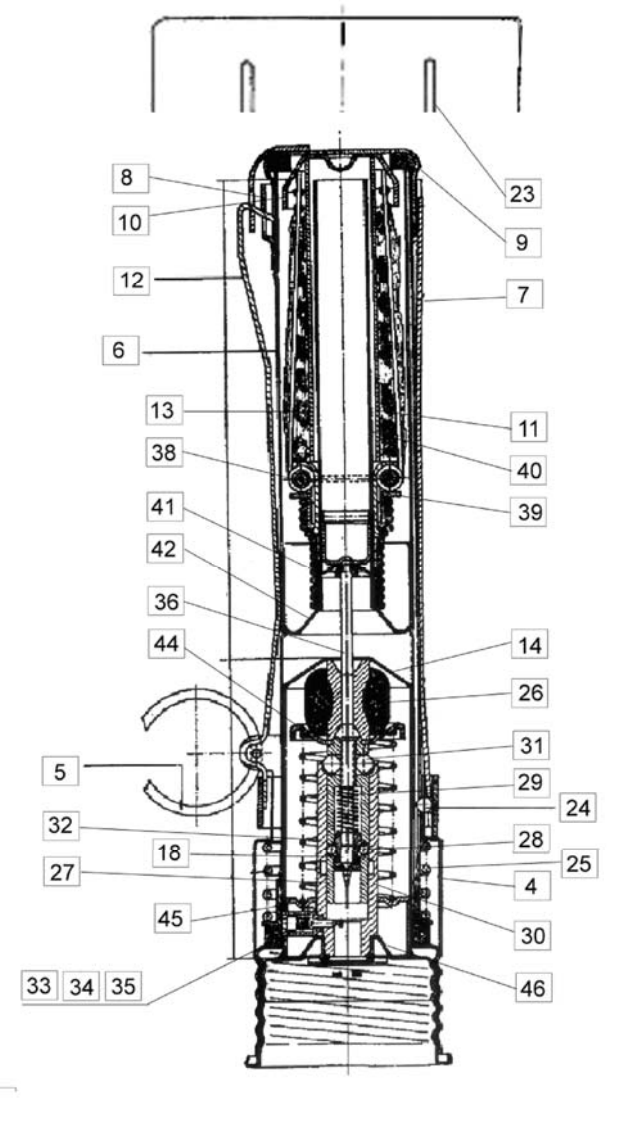


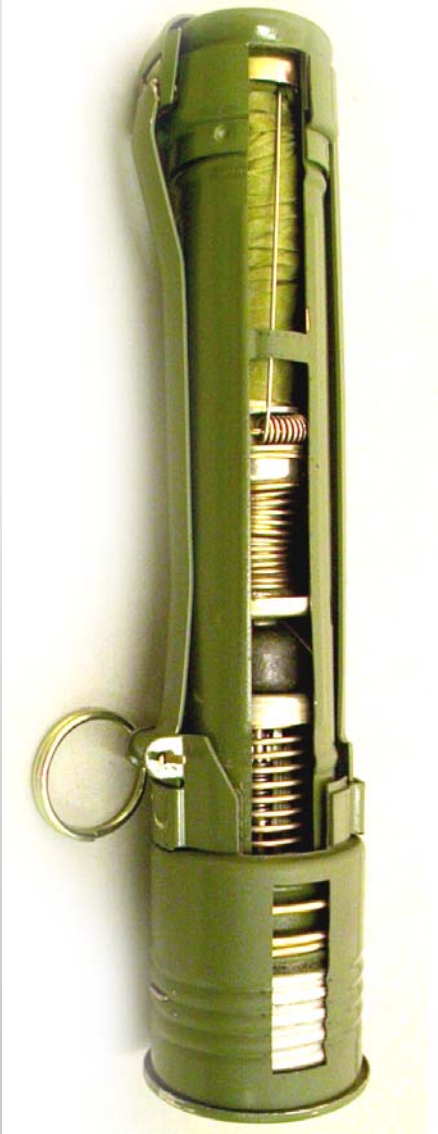


Constituents in the Handle

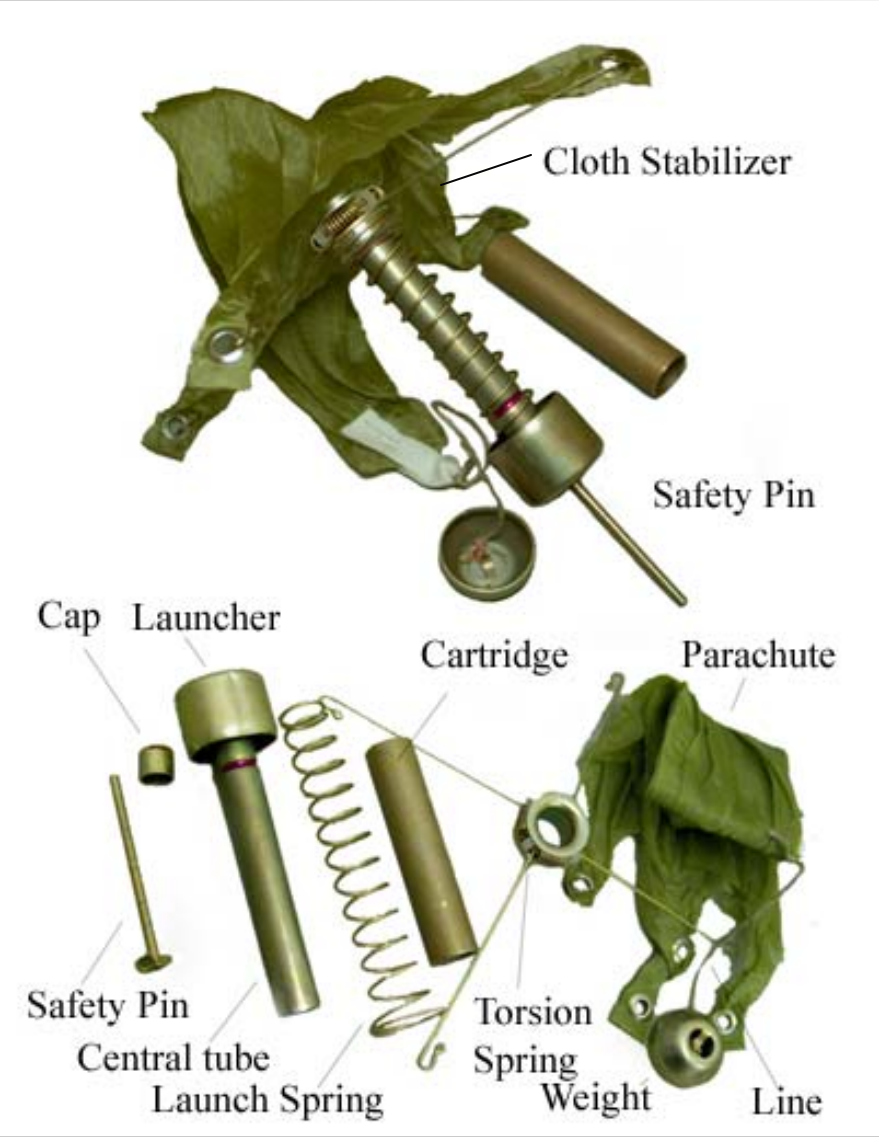


The Handle - Open View

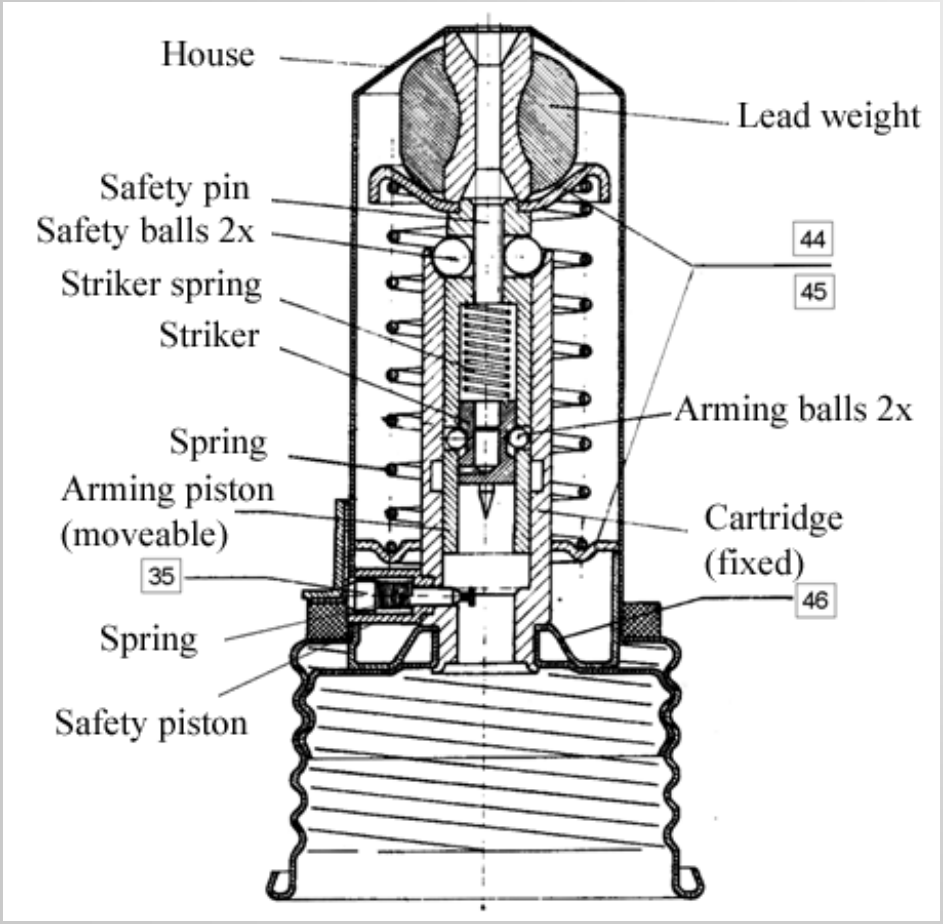




Constituents in the Parachute Assy



Constituents in the Fuze





Abstract

- The accident would most likely be classified in the category “Human error” by the “Geneva International Centre for Humanitarian Demining”
  - That is the most common cause to explosive events at ammunition depots, > 25 %
- To the EOD-instructions
  - treat it as if it is armed
  - don´t try to retake it (take apart the handle)

Approved for public release: Distribution Unlimited PAO Log# 460-09

US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

Utilizing Ball Grid Arrays in High- G Environments

Malcolm Baldrige National Quality Award 2007 Award Recipient

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Fuze Development Center

US Army RDECOM ARDEC Fuze Division
Picatinny Arsenal, NJ

Stephen Redington, PE
973-724-3231

May 21, 2009

NDIA 53rd Fuze Conference - Orlando

Ball Grid Arrays in High-G Environments



- INTRODUCTION
  - The Fuze Development Center
  - New paradigm for development
- The Fuze Reliability Problem
- Variables Involved
- A Methodology for Evaluation
- Guidance / Mitigation Strategies
- Summary

US ARMY RDECOM

The Fuze Development Center
Picatinny NJ, Building 1530



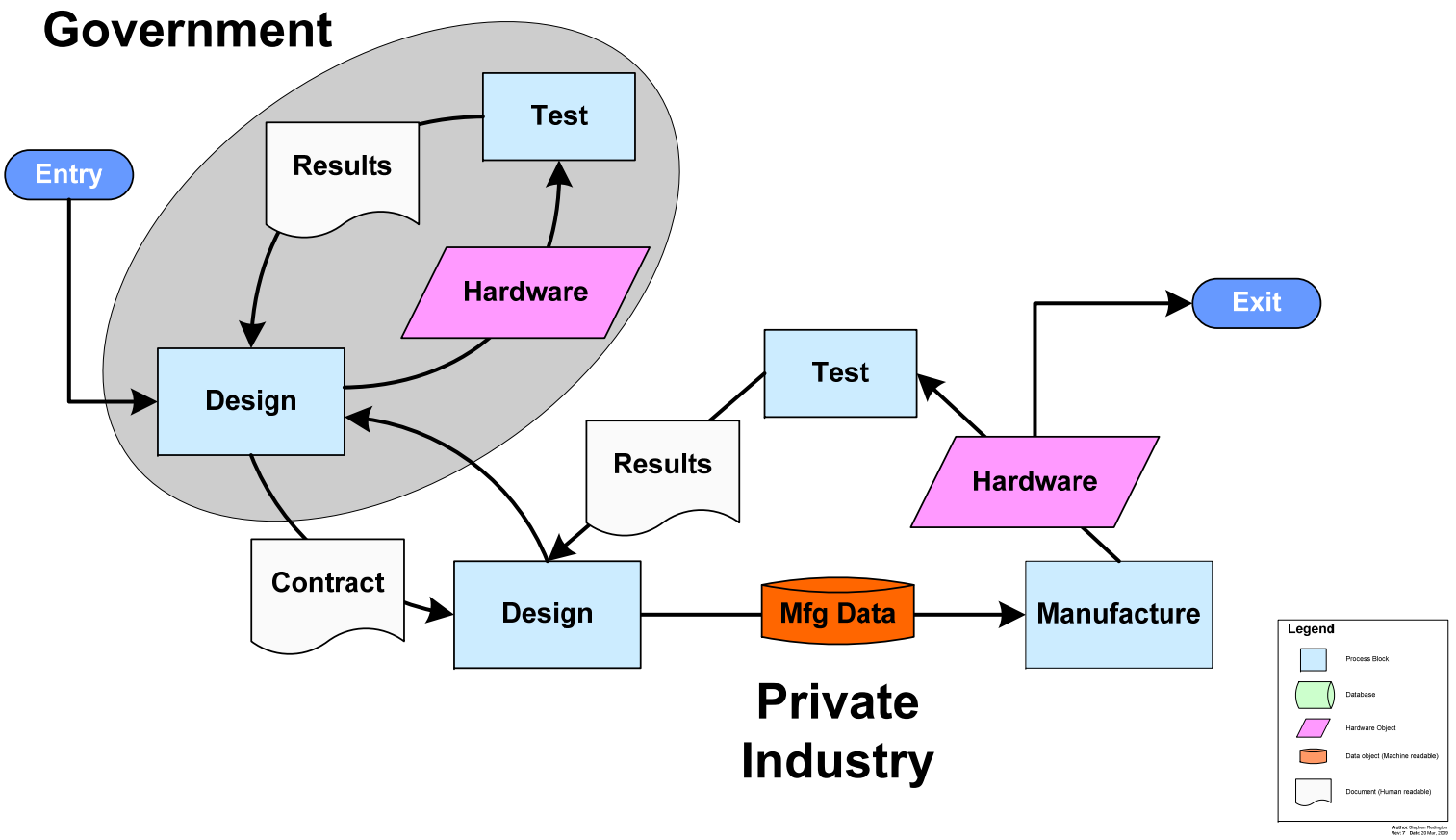
Fuze Development Center Mission:
Accelerate New technology to the Field

Malcolm Baldrige National Quality Award
2007 Award Recipient

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

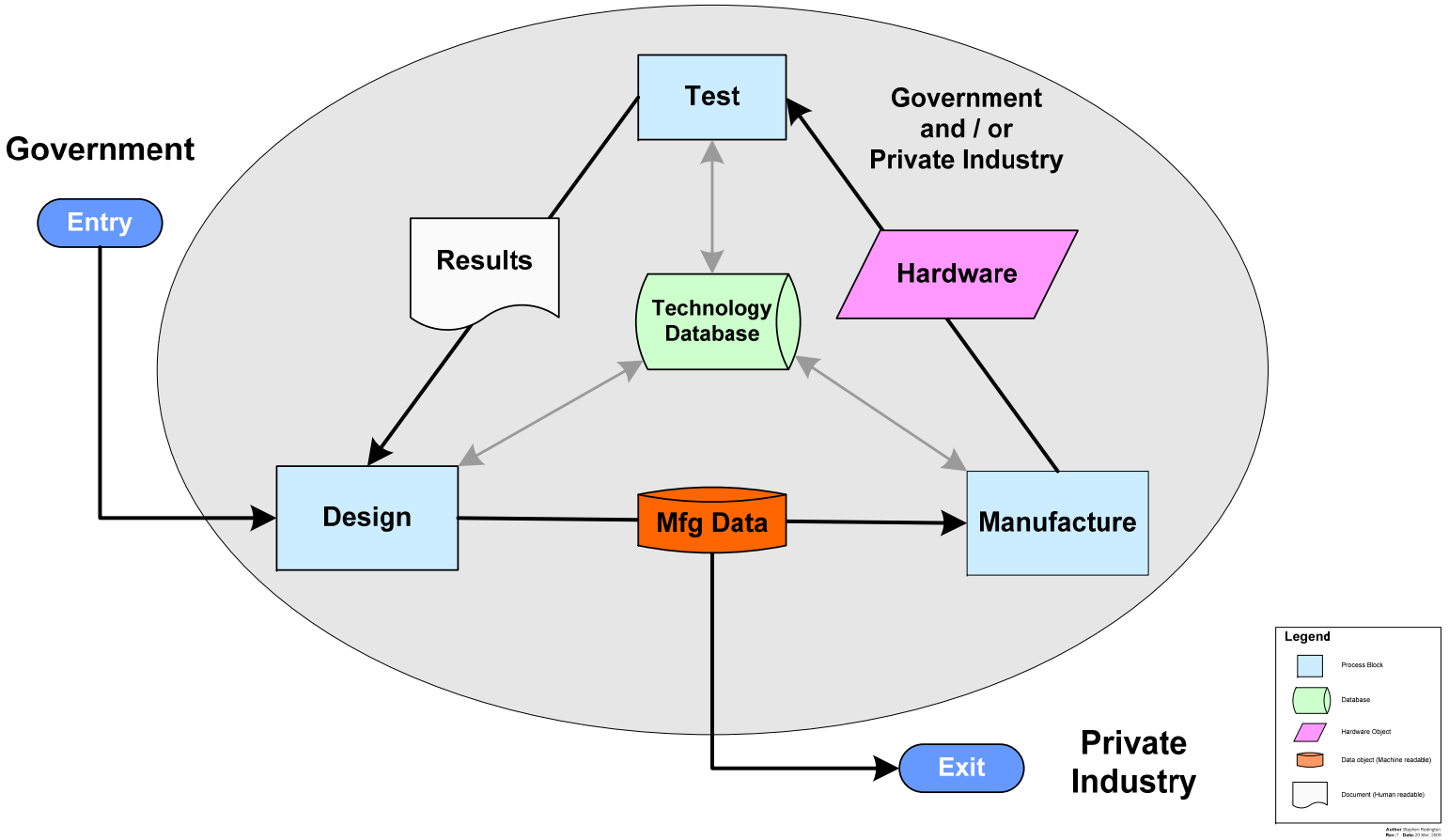
Concept Prototyping

A model for experimentation and development



Integrated Producability

An integrated model for experimentation and product development



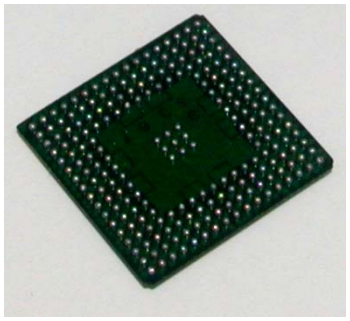
- The Fuze Electronics Reliability Problem
  - Military markets have little or no influence over electronics technology
  - Advanced features of new fuzes require electronics packaging technology developed for commercial markets
    - Cell phones
    - Computers / TV / VCR / Digital cameras & recorders
    - Personal GPS navigation
    - Games / Toys
  - Commercial technology has no long term reliability requirement

- The Problem (continued)
  - Ball Grid Array packaging is new to the fuze community
    - Very little historical data for long term reliability
    - The technology has known shock survivability issues
  - Use of Ball Grid Array (BGA) technology is unavoidable in fuze applications
    - High level of integration / small footprint
    - Preferred over fine pitch leaded components for manufacturing
    - Guided munitions require BGA technology

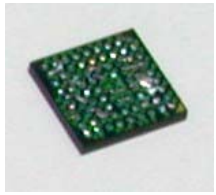
Reliability: What's the difference?

- Commercial environments
  - Short product life cycle (a few years in most cases)
  - Benign storage / operating environment
  - Short storage life / Long service life (2-10 years)
- Fuze environments
  - Long product life cycle (20 years or more expected)
  - Not so benign storage (can be controlled to a degree)
  - Harsh operating environment (thermal & shock)
  - Long storage life / Very short service life (minutes)

BGA Technology is unavoidable in new Fuzes









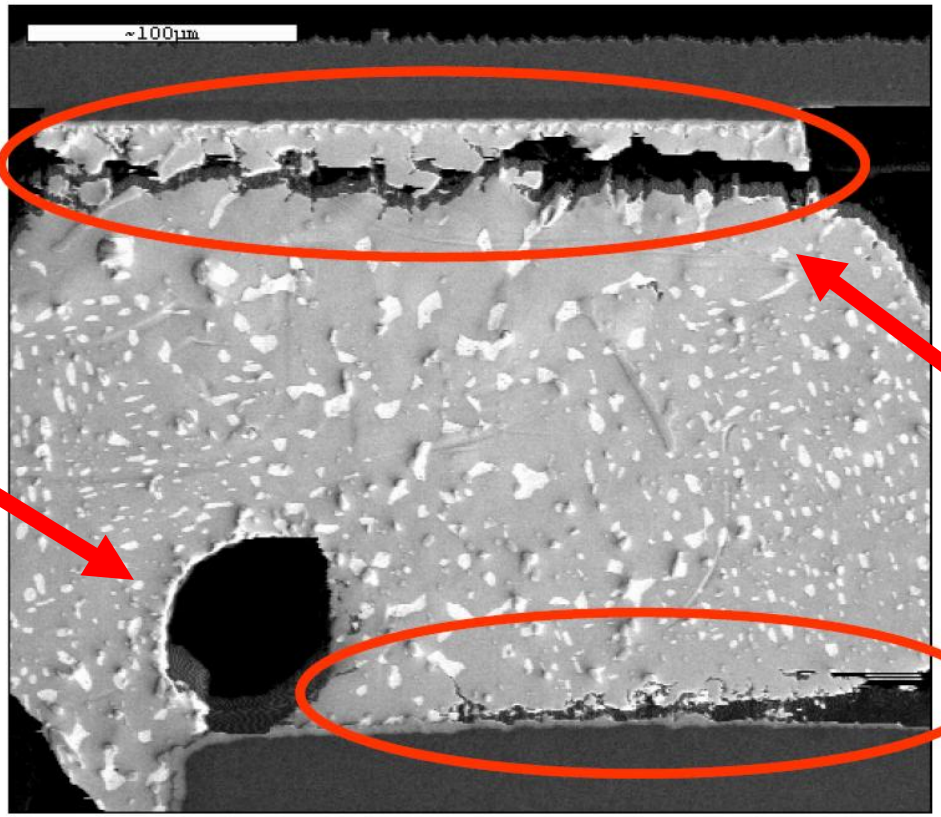


What does this mean for fuze reliability?

BGAs in High-G Environments
Failed solder joint

Stress failure of a lead free BGA in a tin/lead solder process

VOID
(acceptable)



Stress induced failure

Photo courtesy of iNEMI/Sanmina-SCI, Dr Robert Kinyanjui

BGAs in High-G Environments

- Many variables contribute to fuze reliability
  - Solder process / void allowance
  - Axial load orientation
  - BGA package size
  - BGA ball pitch
  - Thermal coefficients (package to board)
  - Thermal environment / Cycling
  - Local power density / Package heat dissipation
  - Potting compounds / Under-fill materials
  - PCB flexing under load

BGAs in High-G Environments Test Methodology

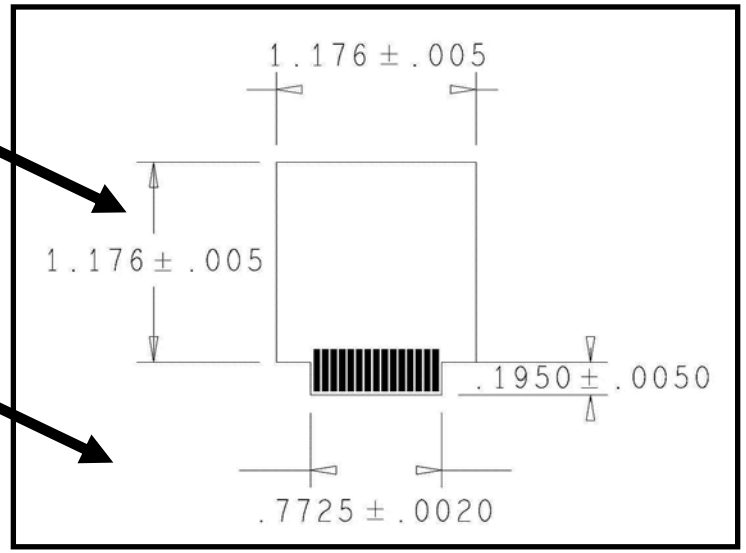
- Industry is investigating several issues
  - Results applicable to fuzing tend to be proprietary
- Fuze Development Center is addressing the problem
  - Test method and vehicle have been developed
  - No hard data to date
  - FDC will pursue remedies in FY10
    - A design guide is the target deliverable
  - More funding / Participants are desired
    - Anybody have some money / time ??

Test Methodology

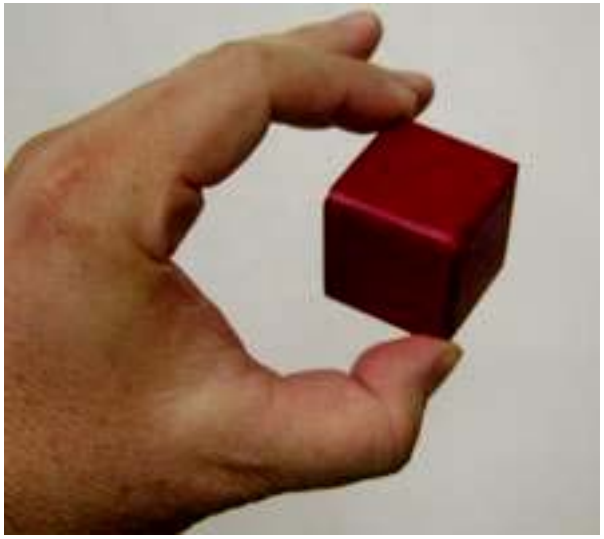
- Test individual technology samples
  - Test programmable BGA packages by daisy chaining I/O to create a simple continuity test
  - Isolate and test one sample at a time be it a package or a process

Standard Test Tile
One sample per tile

Edge connector keeps
PCB cost low

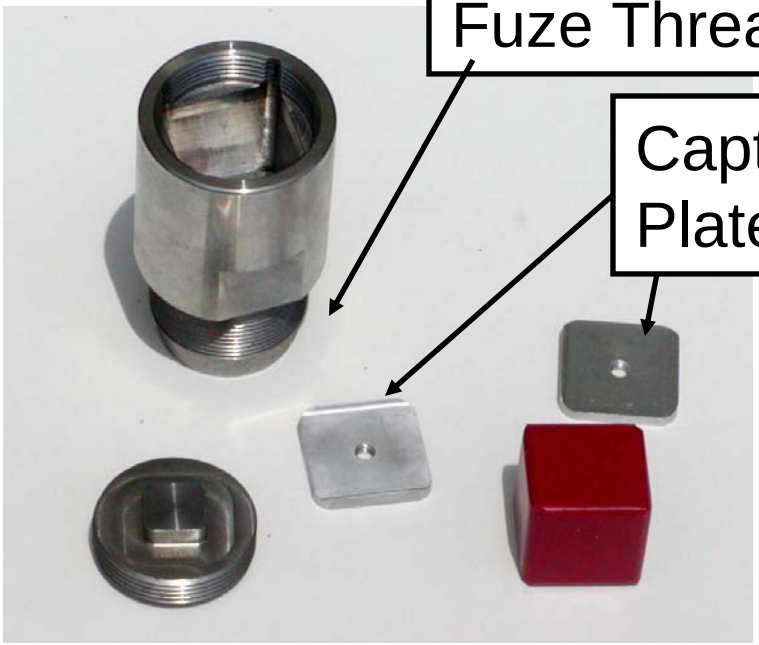


BGAs in High-G Environments Test Methodology



Cubes are gun launched in any axial orientation any number of times. Each sample is individually tested.

Test samples are cast into testable cubes. Up to 3 samples per cube



- No hard data but evidence suggests the following guidance
  - Use leaded packages where possible
  - Choose larger ball pitches over smaller ones
    - Smaller ball size results in higher stress from thermal or shock load
  - Choose smaller packages over larger ones
    - Larger area results in higher stress from thermal or shock load

- Guidance (continued)
  - Use an appropriate under fill
    - Shock hardness improvement has been demonstrated
    - Bad thermal matches will make reliability worse
  - Shock hardness is likely better in compression over sheer (need more data here)
  - Avoid lead free BGAs if at all possible. Explore re-balling to keep in a traditional tin / lead solder process
    - **Do NOT use RoHS BGAs in a tin / lead solder process without changing the oven profile**
  - Control all process variables
    - Oven profile, paste formula, under fill, etc…

Conclusions

- Electronics technology is rapidly evolving and resultant long term reliability issues need to be addressed
- RoHS initiatives are creating new reliability concerns before existing tin / lead BGA issues can be answered

Questions

Fuze Development Center

US Army RDECOM ARDEC Fuze Division
Picatinny Arsenal, NJ

Stephen Redington, PE
973-724-3231

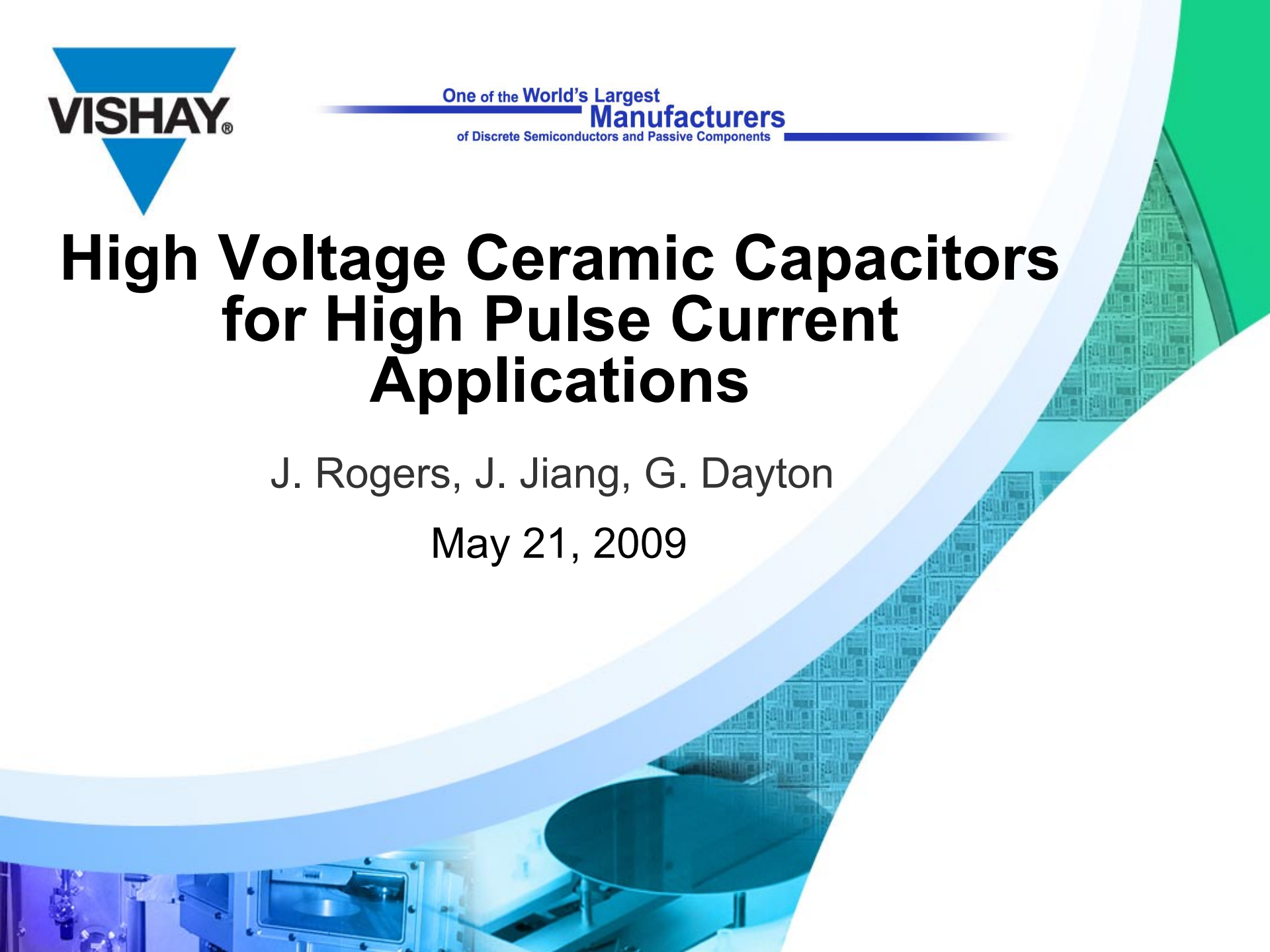
VISHAY

One of the World's Largest Manufacturers of Discrete Semiconductors and Passive Components

High Voltage Ceramic Capacitors for High Pulse Current Applications

J. Rogers, J. Jiang, G. Dayton

May 21, 2009



Control Discharge Capacitor (CDC) Development

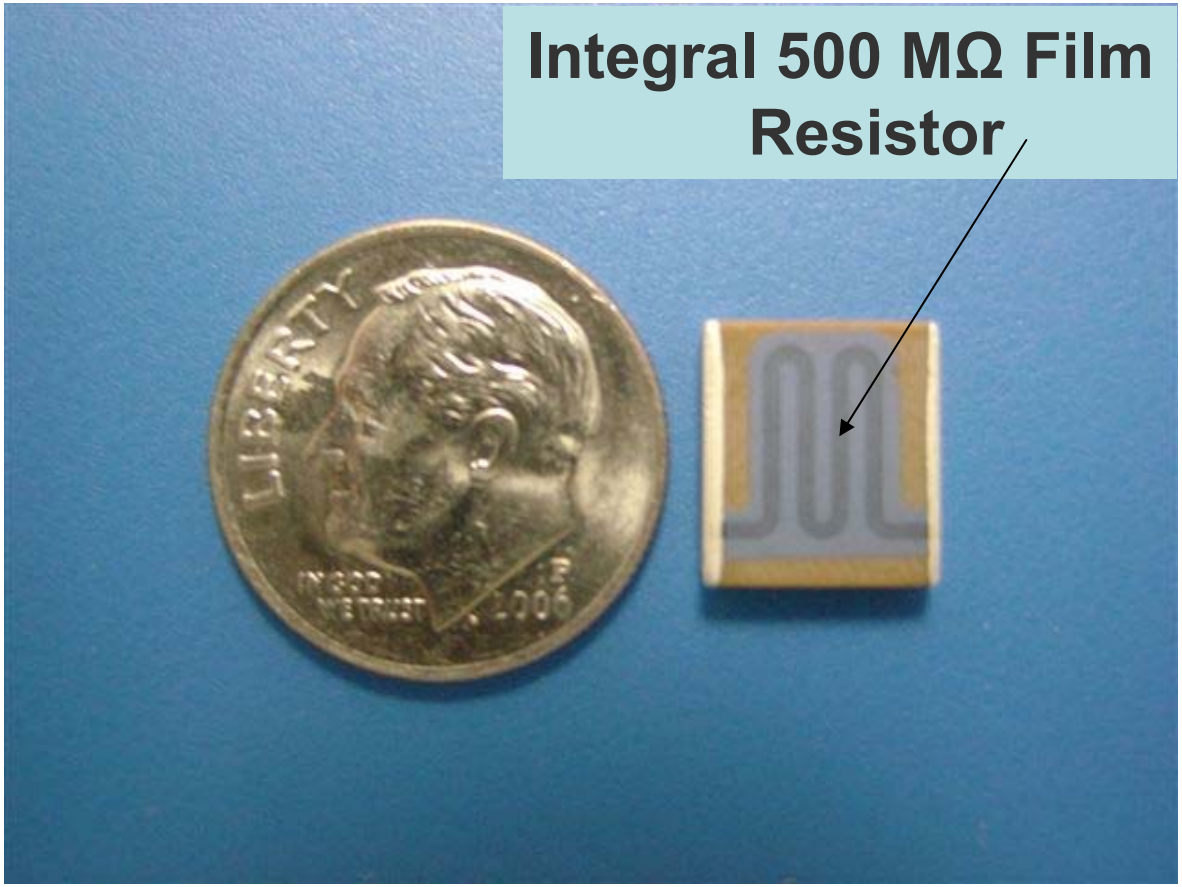
- Vishay developed a new X7R (X5P) dielectric system having a Low Coefficient of Electrostriction (Low Q_E).
- The Low Q_E material has less mechanical strain when an electric field is applied.
- This new material is incorporated in MLCCs for high voltage and high pulse current applications.
- The CDC was developed specifically for Electronic Fuze applications.

Overview

- **CDC properties**
- **Comparison of Electrical Characteristics**
  - Voltage Breakdown Levels (VBD)
  - Temperature Coefficient of Capacitance (TCC)
  - Voltage Coefficient of Capacitance (VCC)
- **Pulse Discharge Current of Experimental CDCs**
- **Fireset Ringdown Measurements at (-40, 25, 75) Celsius**
- **Conclusions**

Controlled Discharge Capacitor

CDC - 3640, 180nF, 1500Vr

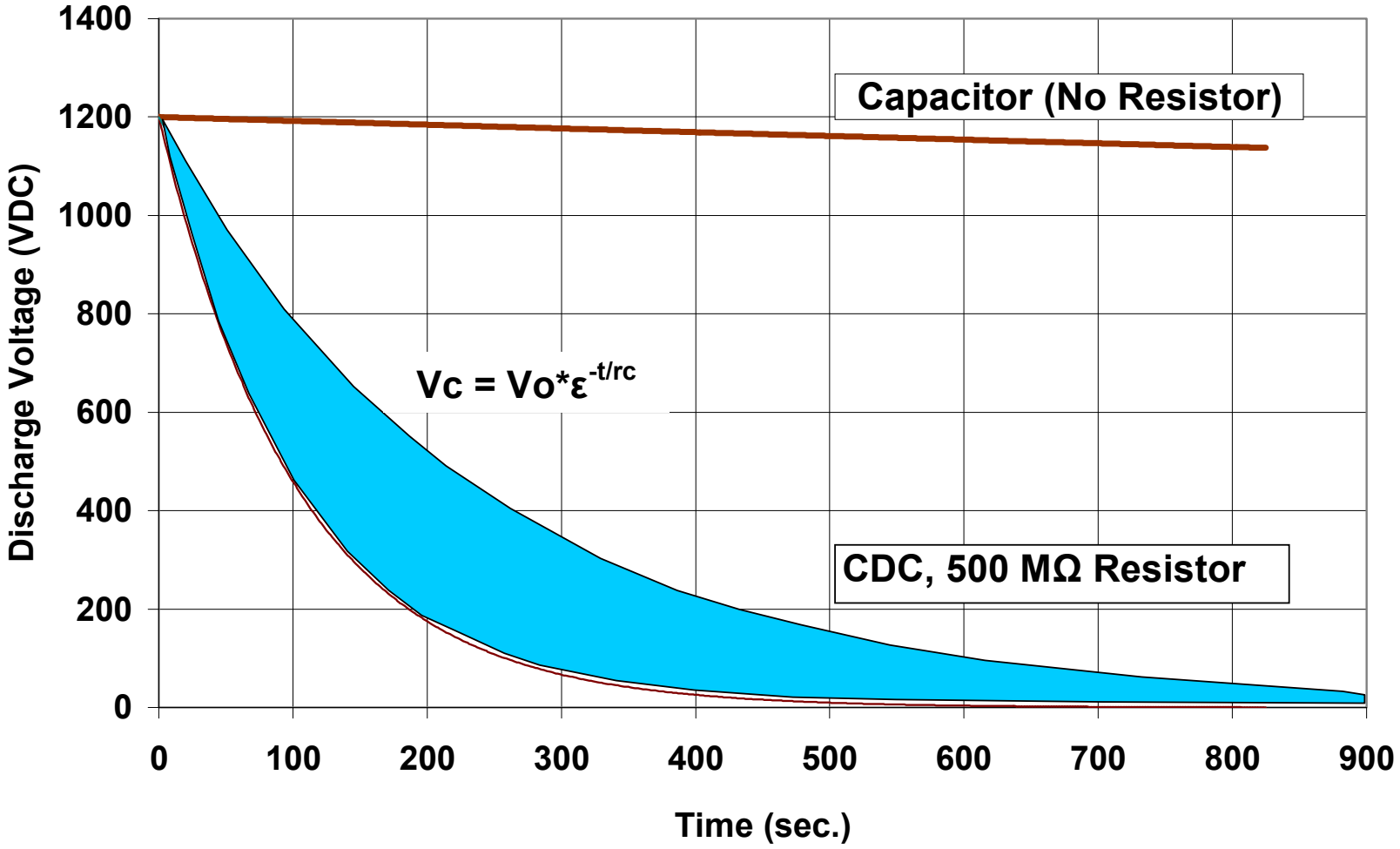


CDC Discharge Time

- The discharge voltage vs. time curve of a CDC is compared to that of a regular high voltage capacitor.
- The capacitor with no parallel resistor maintained 95% of the initial charge voltage 800 seconds after the bias is removed.
- The CDC safely discharges below the firing threshold and closely follows a typical RC discharge function $Vc = Vo*\varepsilon^{-t/rc}$

Self Discharge Curve

CDC: 4044, 330nF, 1500V



CDC Dimensions

CDC DIMENSIONS inches [millimeters]			
P/N CASE CODE	**LENGTH**	**WIDTH**	**MAXIMUM THICKNESS (T)**
VJ3640	0.360± 0.015 [9.14 ± 0.38]	0.400 ± 0.015 [10.20 ± 0.38]	0.086 [2.18]
VJ4044	0.400± 0.015 [10.16 ± 0.38]	0.440 ± 0.015 [11.17 ± 0.38]	0.120 [3.05]

Comparison of Electrical Characteristics

- Three experimental CDC capacitor designs
- Testing:
  - Voltage breakdown,
  - Temperature coefficient
  - Voltage coefficient

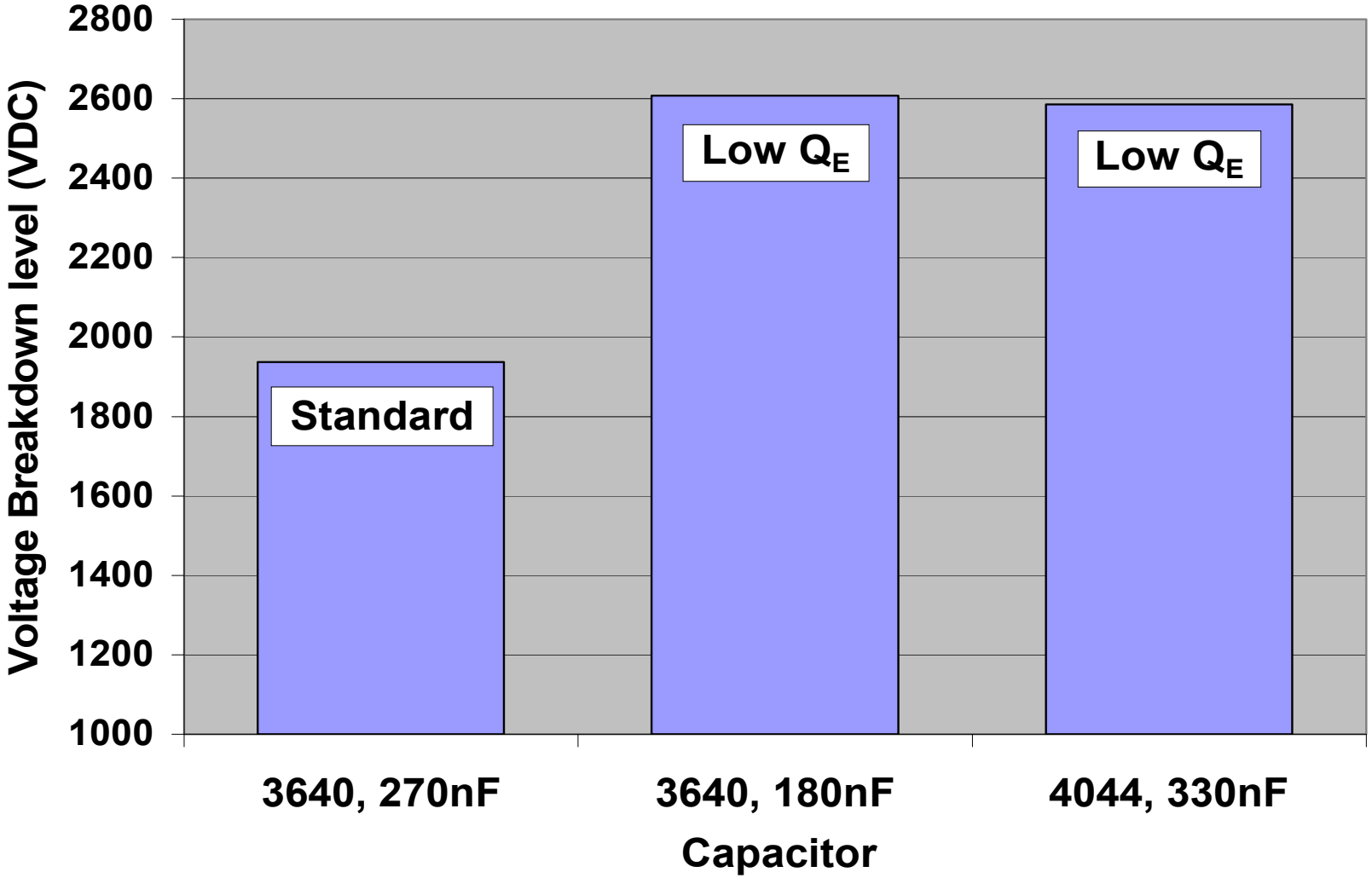
Experimental Capacitors

Case Size	4044	3640	3640
Dielectric	Low Q_E	Low Q_E	Standard X7R
Capacitance	330 nF	180 nF	270 nF
DC Rated Voltage	1500	1500	1500

Voltage Breakdown Levels

- Three 1500V rated CDC designs are subjected to voltage breakdown analysis.
- 50 samples of each design tested to failure by applying a uniform voltage ramp at a rate of 500 VDC/sec (EIA-198-2-E. Method 103)
- Capacitors using low Q_E dielectric averaged 600V higher VBD – a 33% improvement over the standard dielectric.

Voltage Breakdown Levels of Experimental Capacitors



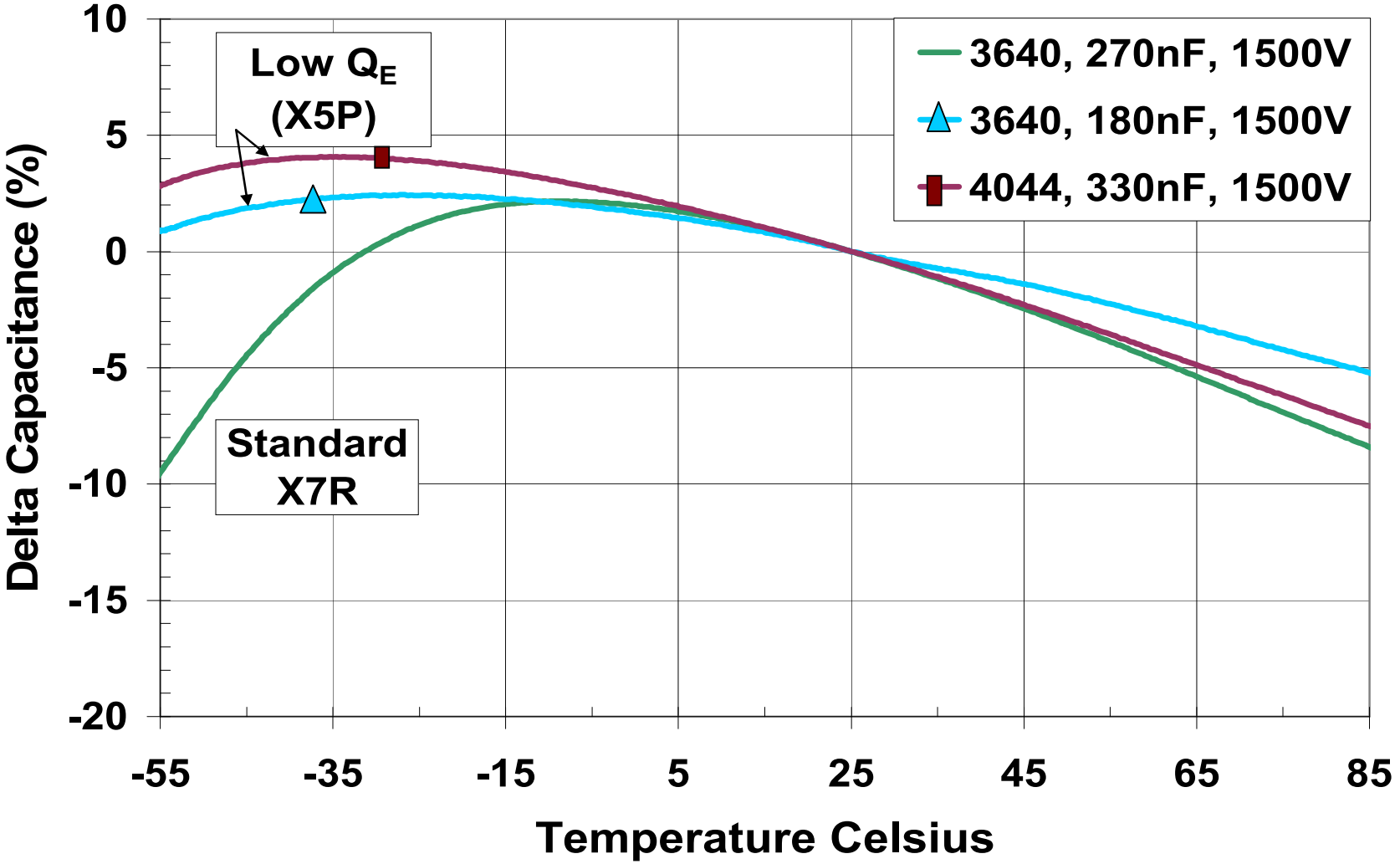
Voltage and Temperature Coefficient of Capacitance

- EIA Class II dielectrics utilize ferroelectric materials.
- Capacitors made with these dielectrics will undergo a capacitance delta when either a bias voltage is applied or ambient temperature conditions change.
- Capacitors made with the low Q_E dielectric retain more capacitance when subject to voltage and temperature compared to standard X7R capacitors.

Temperature Coefficient of Capacitance

- Low Q_E dielectric has improved capacitance stability across the operating temperature range and meets X5P TC Code.
- X5P Code: Capacitance delta will not exceed ± 10% within a -55 to 85 °C operating temperature.
- Below 25 °C the capacitance delta of Low Q_E dielectric is positive, affording more energy at the fireset's bias voltage.

Temperature Coefficient of Capacitance



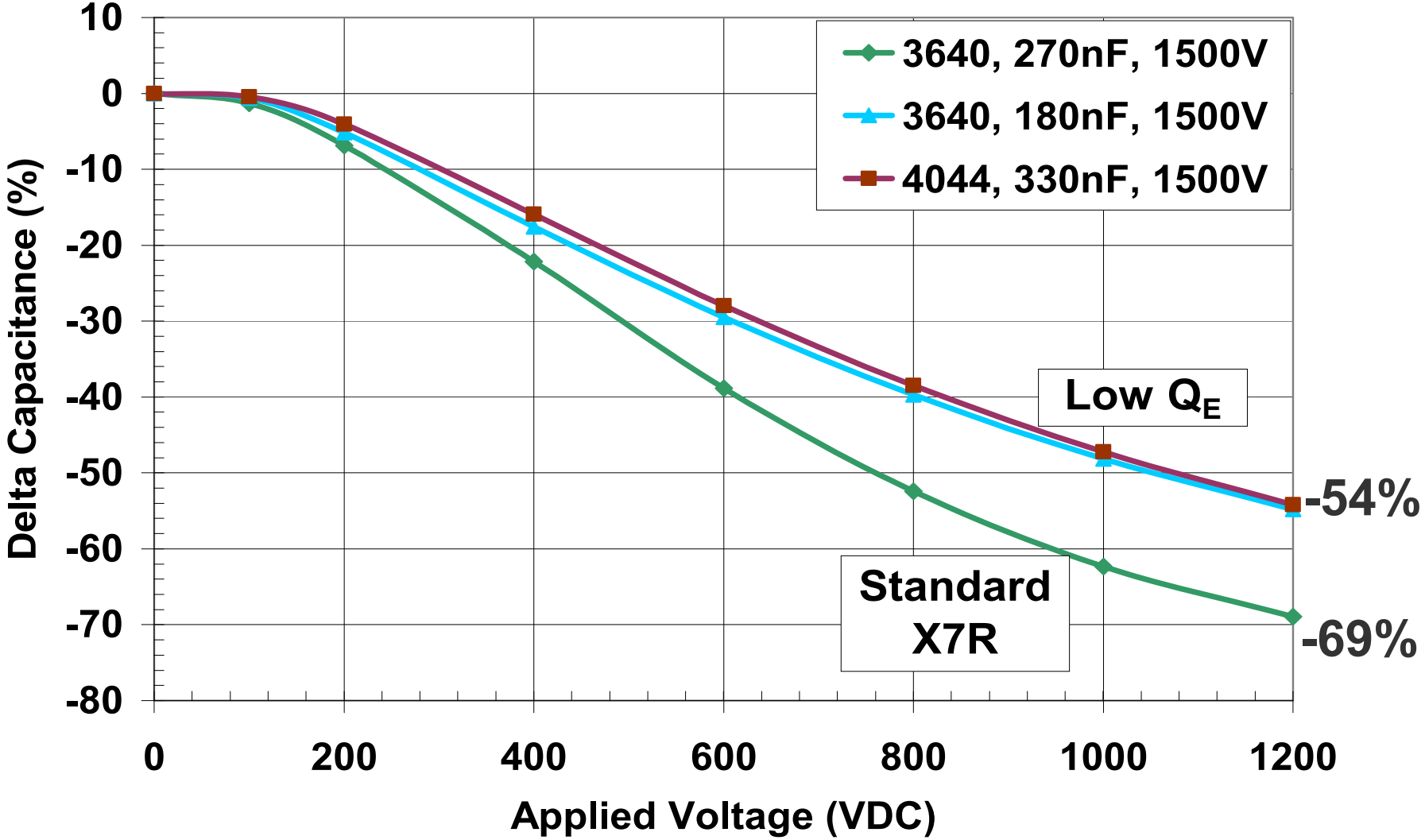
Voltage Coefficient of Capacitance

- Because of the improved dependence of K on voltage, the low Q_E dielectric exhibits decreased capacitance loss at the use voltage.

- At a bias of 1200 VDC capacitors using low Q_E dielectric material have 15% improved capacitance retention over standard dielectric.

Voltage Coefficient of Capacitance

Ambient test conditions (T = 25 °C)

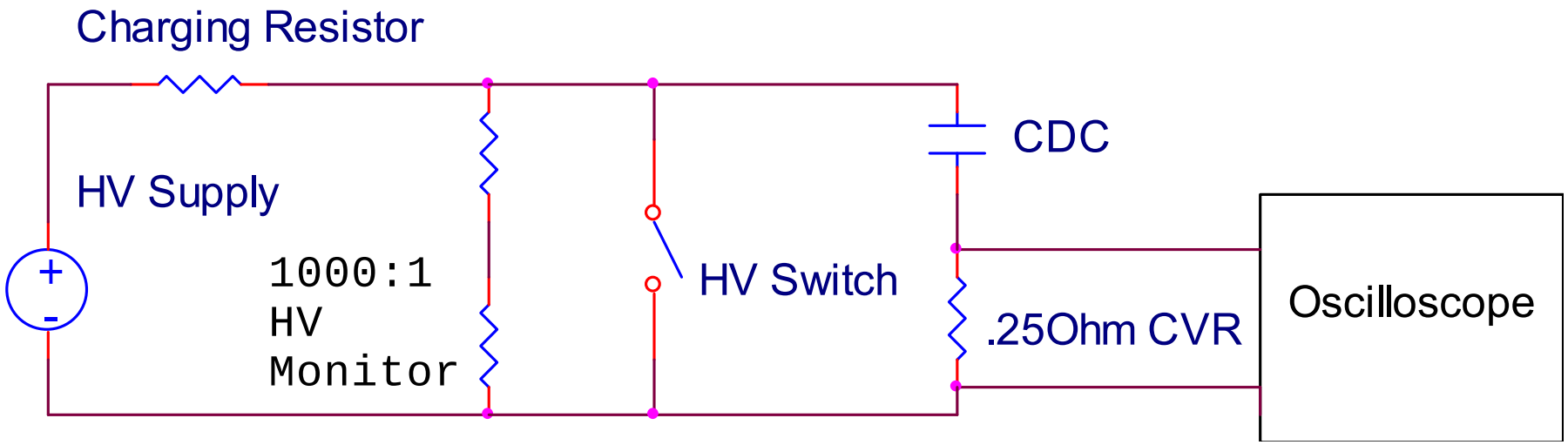


Pulse Discharge Current

- To obtain the pulse discharge currents of the experimental capacitors a capacitor discharge unit is constructed per Figure A-1 of MIL-DTL-23659E.

- The experimental capacitors are charged to DC voltage levels and then discharged through a low inductance loop and a 0.25 Ω current viewing resistor.

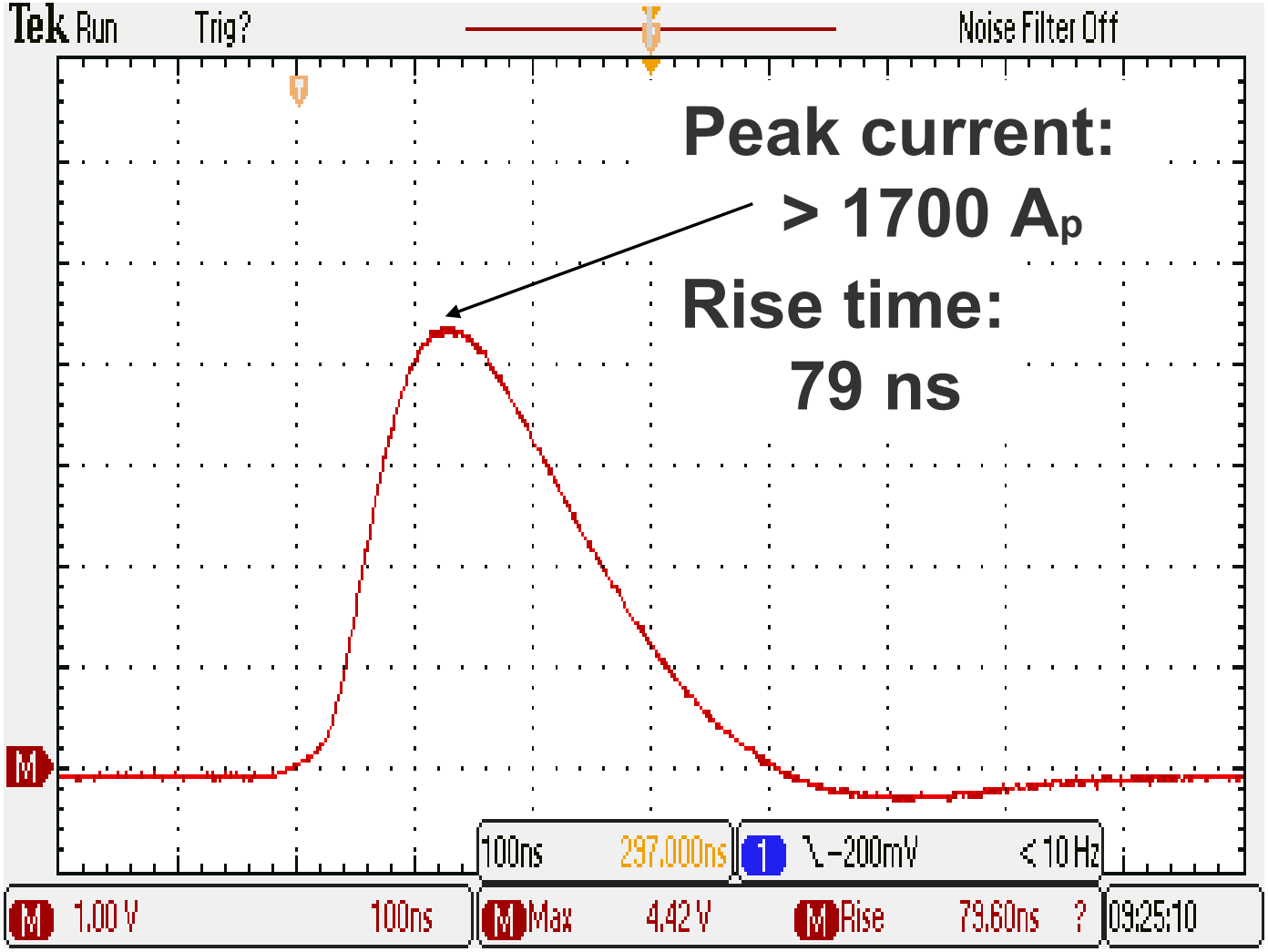
Capacitor Discharge Unit



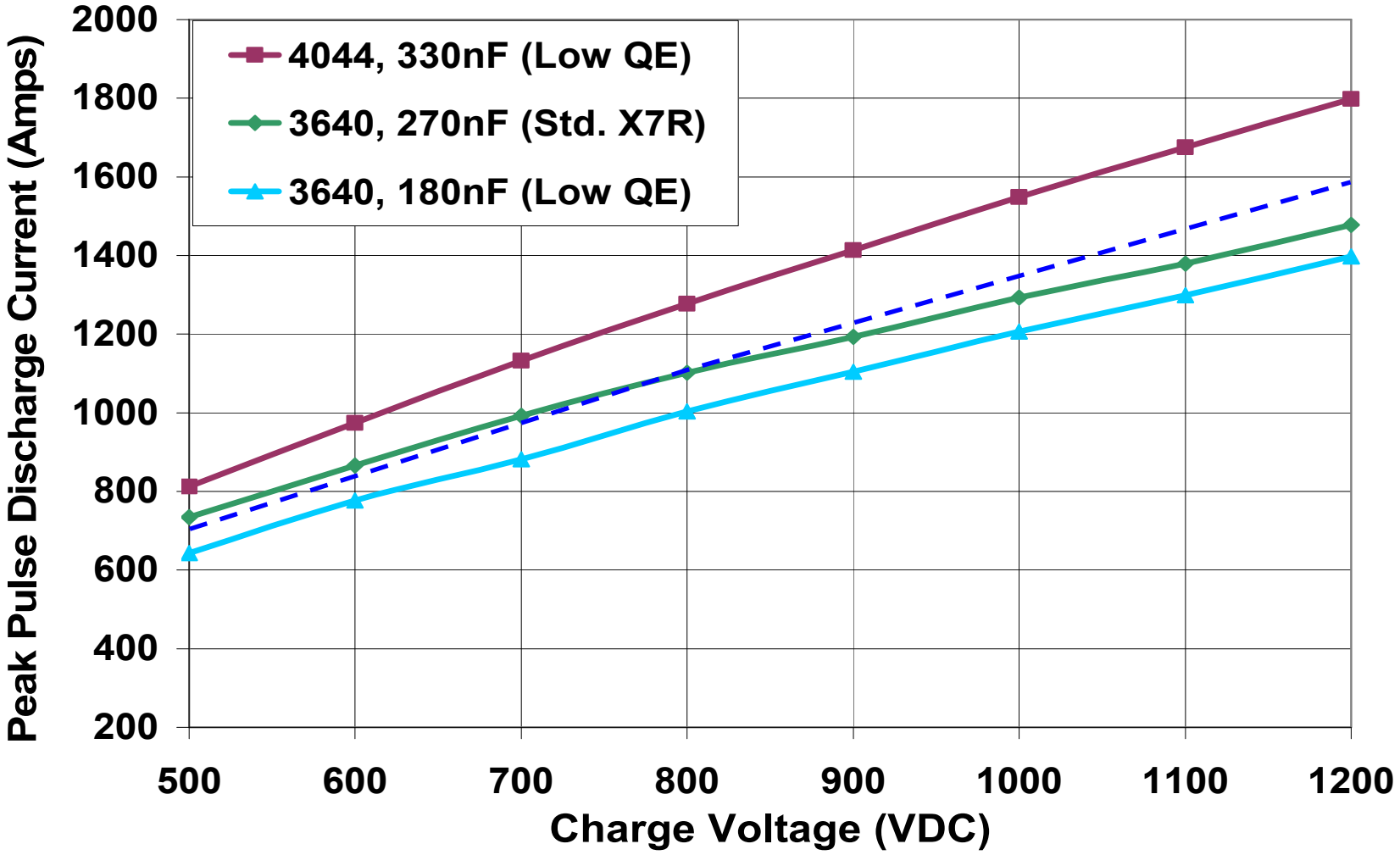
Per Figure A-1 of MIL-DTL-23659E

Discharge Pulse

CDC: 4044, 330nF, 1500Vr



Discharge Current vs. Charge Voltage



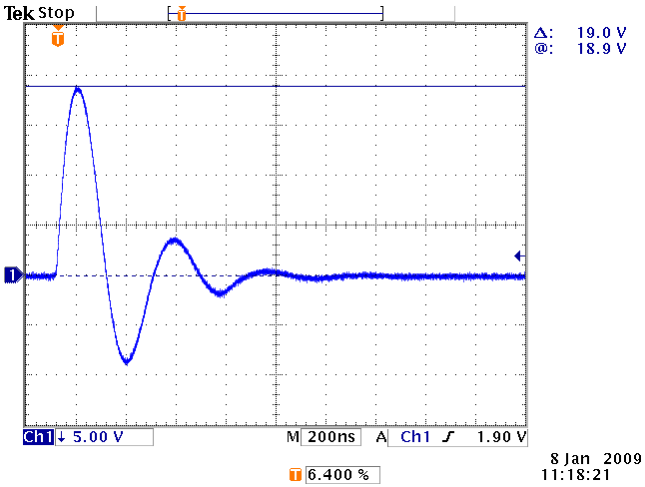
Pulse Discharge Ringdown

- **4 types of fireset capacitors tested with a low impedance fireset:**
  1. 120nF, 3040, 1500V Control Cap A
  2. 120nF, 5090, 1500V Control Cap B
  3. 270nF, 3640, 1500V Vishay CDC
  4. 330nF, 4044, 1500V Vishay CDC

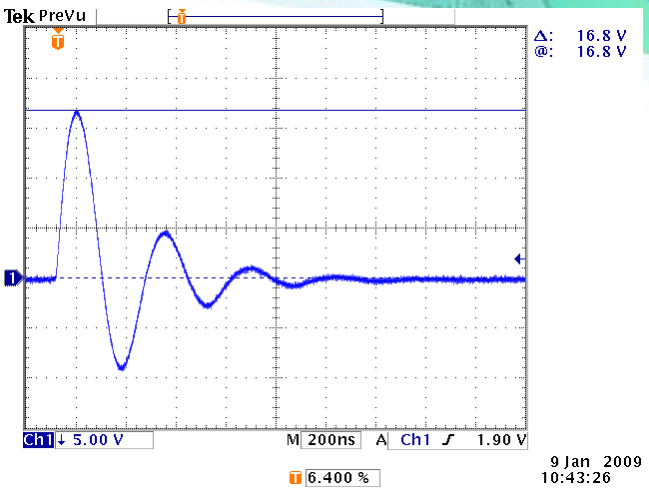
- Test data supplied by PerkinElmer
- Control Caps A&B are commercially available pulse discharge capacitors

Cold Ringdowns

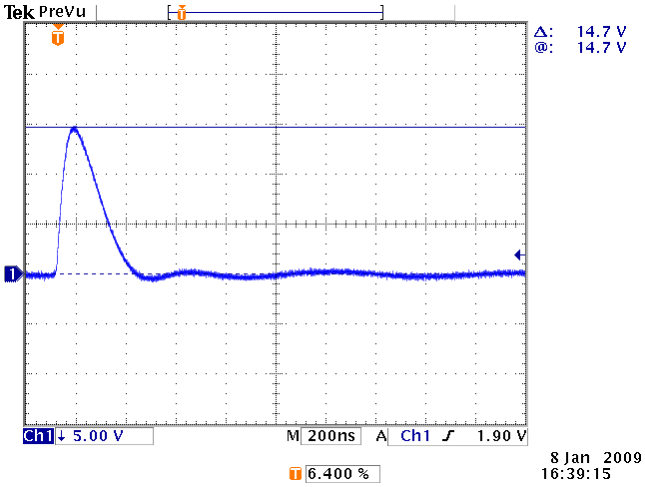
(T = - 40 °C)



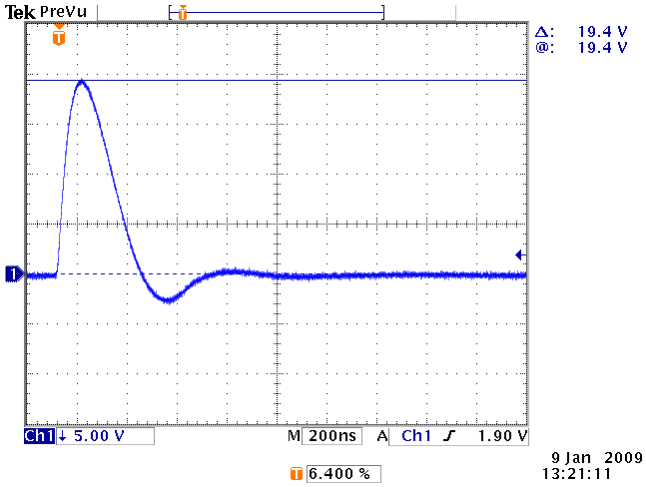
Control A: 1890 A peak



Control B: 1680 A peak



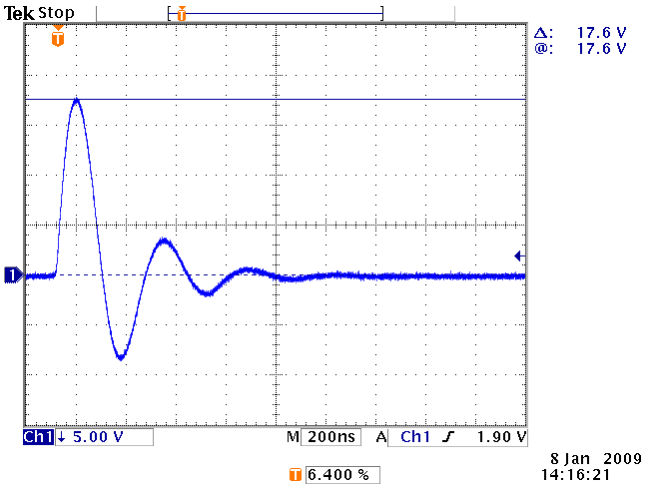
Vishay 3640: 1470 A peak



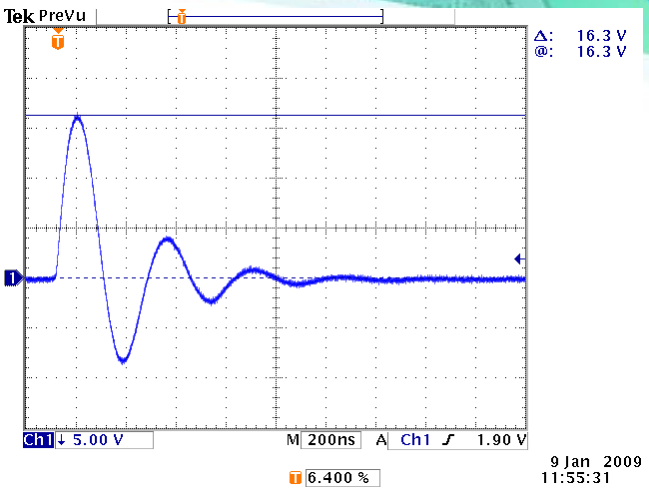
Vishay 4044: 1940 A peak

Ambient Ringdowns

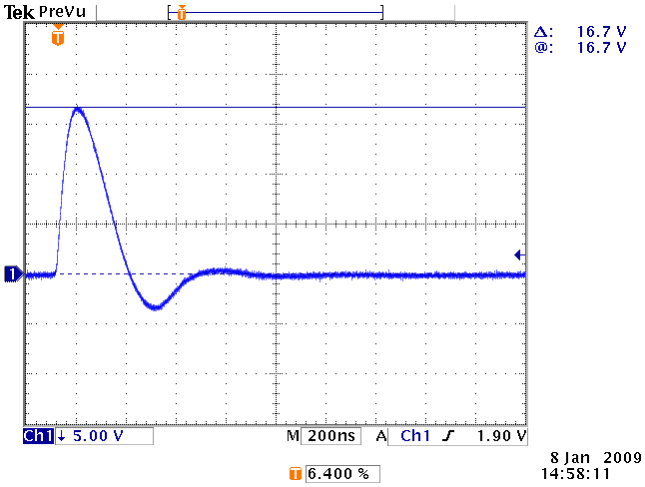
(T = 23 ± 10 °C)



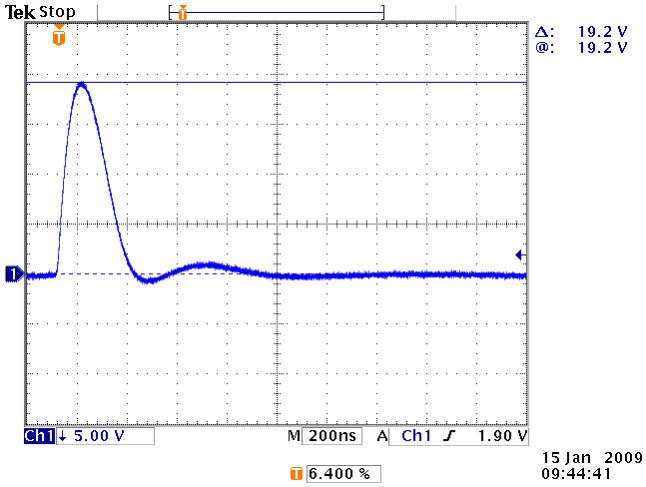
Control A: 1760 A peak



Control B: 1630 A peak



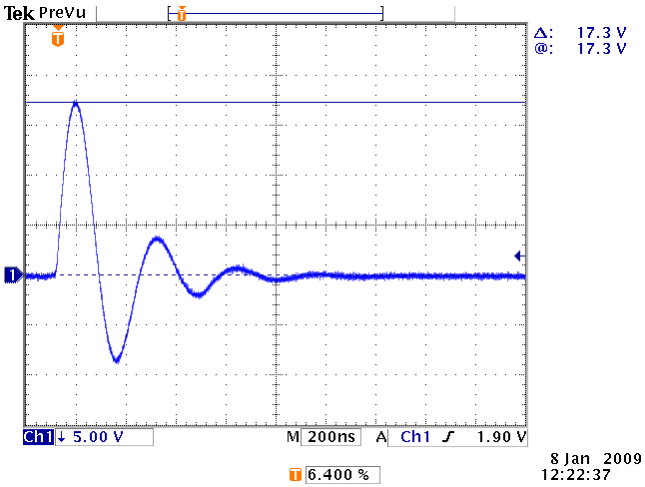
Vishay 3640: 1670 A peak



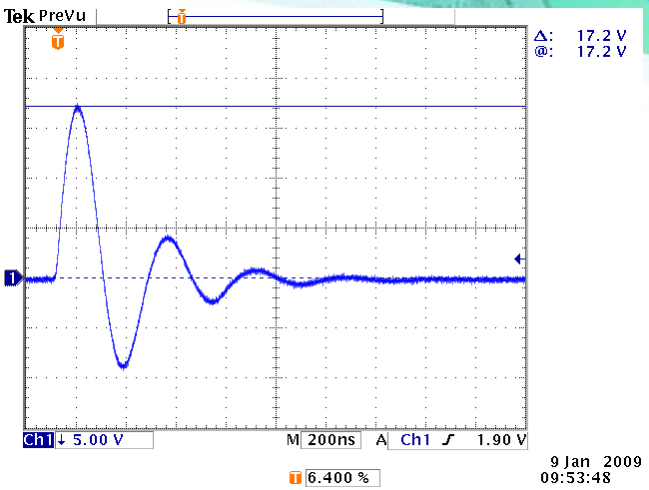
Vishay 4044: 1920 A peak

Hot Ringdowns

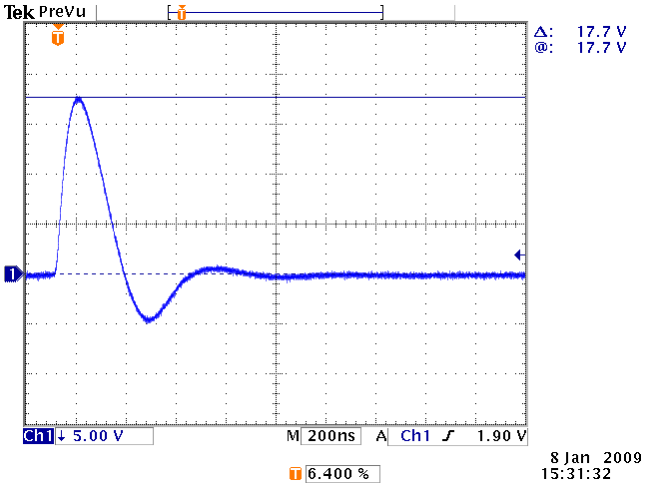
(T = +75°C)



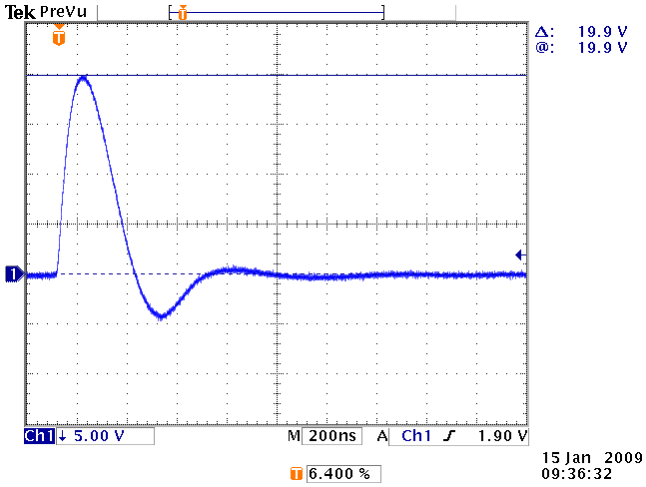
Control A: 1730 A peak



Control B: 1720 A peak



Vishay 3640: 1770 A peak



Vishay 4044: 1990 A peak

Summary of Pulse Discharge Ringdown comparison

Temperature (°C)	Control Capacitor A (Ap)	Control Capacitor B (Ap)	Vishay Capacitor Standard X7R (Ap)	Vishay Capacitor Low Q_E (Ap)
-40	1890	1680	1470	1940
+25	1760	1630	1670	1920
+75	1730	1720	1770	1990
Current Average	1793	1677	1637	1950
Current Spread	160	90	300	70

- Low Q_E CDC supplied the highest peak current with the least amount of deviation.
- Low Q_E CDC has better controlled energy delivery over temperature.

Conclusions

- Low Q_E material is more temperature stable than standard material.
- Low Q_E material is more voltage stable than standard material.
- CDC exhibits high VBD and high discharge currents.
- Provides controlled energy delivery range over temperature.
- CDCs have high energy levels to fire EFIs in a fireset circuit.

Acknowledgements

- Vishay wishes to thank PerkinElmer Corporation of Miamisburg, OH. for providing fireset comparison data.

- Special thanks to Vito Coppola, Ken Kolesar, Alice Whitcher, Barbara Primerano for support in developing, fabricating and testing this product.

CDC Electrical Specifications

Specification	Dielectric X5P (Low Q_E)
Temperature Range	(-55 to 85) °C
Temperature Coefficient	± 10% max.
Dissipation Factor @1kHz, 1Vrms, 25 °C	2.5% max
Voltage Range	(1000 - 1500) VDC
Insulation Resistance @ 25 °C	100,000 MΩ minimum or 1000 ΩF, whichever is less.
Integrated Resistor	500 MΩ ± 30%
Capacitance Range	(10 - 330) nF

Questions?



Tek Ord

CHEMRING GROUP PLC

Dent Block Acceptance Test Susceptibility

Robert Savoyski
Andy Konst

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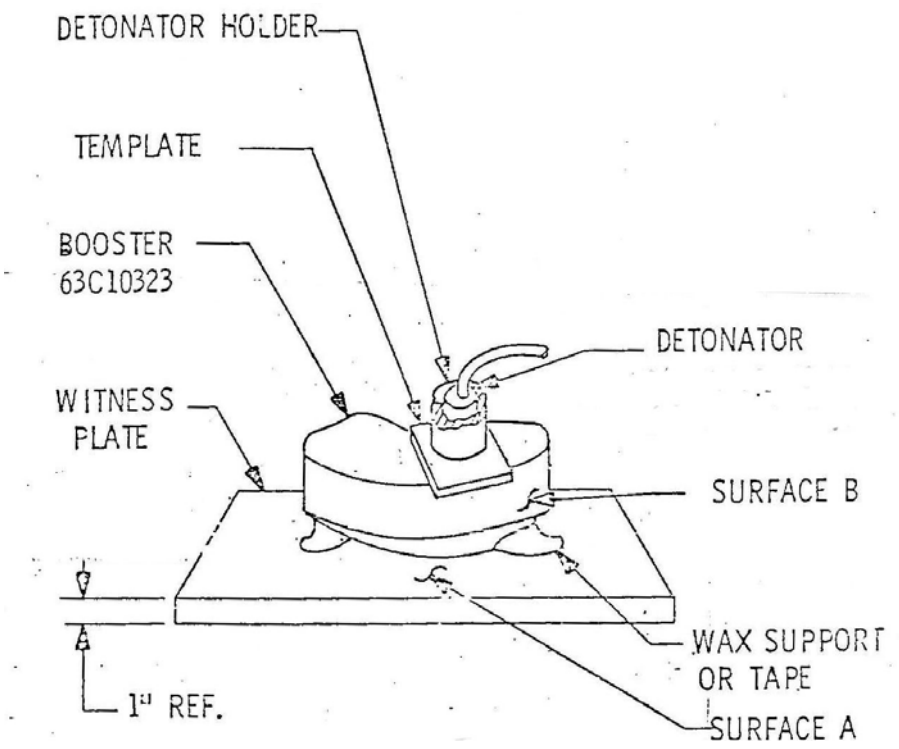
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Failure to Detect Change

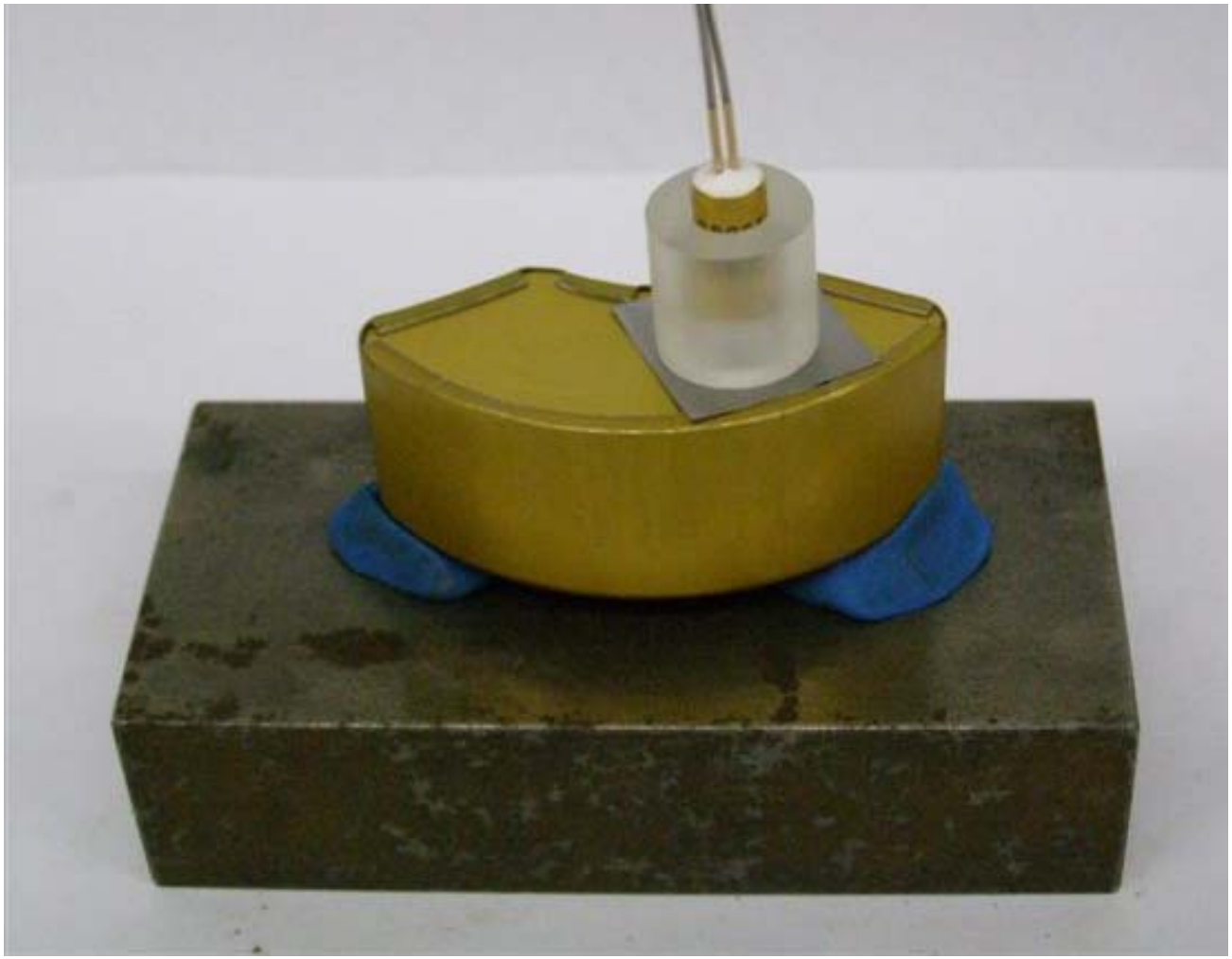
Investigation of a Change in Propagation Reliability for Detonator/Booster Interface after dent testing failed to detect the change

Overview

- MK 80 Bomb explosive train
- Simulation for testing



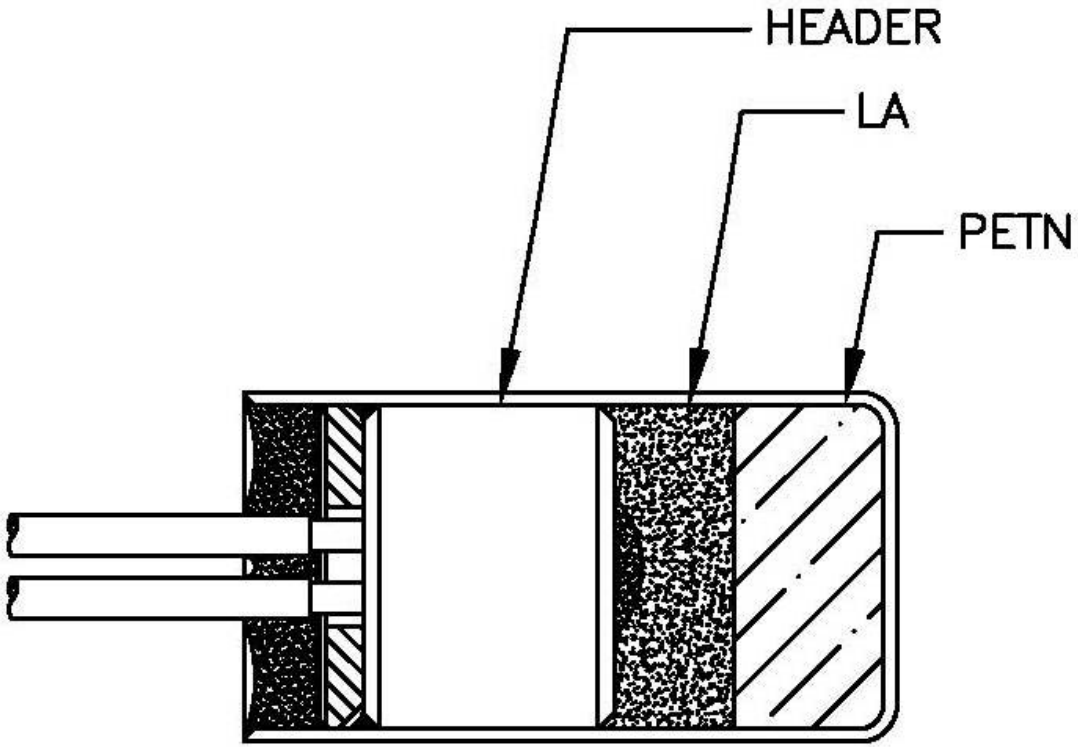
Test Set-up



History of Detonator Design

- Original: Plastic plug, epoxy seal, aluminum cup (AF 62A11810)
- Redesign: Glass header, hermetic solder seal, plated stainless steel cup
- Redesign reliability verified
- Witness block dent criteria confirmed

Detonator Construction



Problem

- Failure of Detonator to initiate Booster discovered during periodic interface testing
- Change in reliability of explosive transfer
- Historically: 30% margin on 99.9% reliability at 95% confidence
- Recently: 50% failures
- Detonator witness block testing demonstrated nominal detonator characteristics

Booster Propagation Data

Det. Lot	Cup Thk	Booster Func. (Req'd. 5.9 mm)	Bruceton 50% Pt.(mm)
99H001-001	0.0105		10.67
02H001-008	0.0105		11.04
06F003-001	0.0105	5/5	
07K003-005	0.0115	3/14	
08A003-006	0.0115	20/22	

Tek Ord

Chemring Group plc

Dent Data

Lot	Avg Dent	Max Dent	Min Dent	Cup Thk
99H001-001	0.020	0.021	0.019	0.0105
02H001-008	0.020	0.021	0.018	0.0105
04L002-002	0.021	0.022	0.020	0.0105
06F003-001	0.020	0.021	0.018	0.0105
07K003-005	0.022	0.025	0.021	0.0115
08A003-006	0.020	0.023	0.018	0.0115

Investigation of Variables

- Booster changes
- Detonator cup changes
- Lead Azide changes
- PETN changes
- Manufacturing process changes
- Test set-up changes

Detonator Construction Variables Testing

Parameter	Function Results 8mm	9mm	10mm
0.0115 cup end thk	1F/2S	3F/2S	2F
0.0105 cup end thk	-	4S	1S
Normal PETN qty	1F/2S	3F/5S	1F/1S
Increased PETN qty	-	1S	1F
Normal DLA qty	2S	3F/1S	1F
Increased DLA qty	-	1F/2S	1S
DLA	1F/1S	2F/5S	1F/1S
SPLA	1S	1F/1S	1F

Summation

- Detonator cup end thickness had greatest effect
- Flier plate transfer mechanism likely
- No other strong effects noted
- Another unidentified variable contributed to problem
- Additional increase in reliability desired

Booster Propagation Data

Det Lot	Variable Tested	Bruceton 50% Pt.(mm)
99H001-001	Std Const	10.67
02H001-008	Std Const	11.04
S001	0.0105” cup thk	8.25
S002	18% inc DLA	8.75
S003	12% inc PETN	9.21
08M004-001	38% inc PETN	9.10

Effort to Increase Margin

- Increased LA: improved results
- Increased PETN quantity: greater effect

Final Conclusions

- Interface common to many explosive trains
- A small change in cup material thickness within drawing requirements had an unexpected change in explosive train performance
- Changes within normal tolerances may result in unexpected results

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MINISTÈRE DE LA DÉFENSE

Intelligent fuzing for penetrating munitions: experiments and analysis of representative configurations

53nd Annual Fuze Conference

Lake Buena Vista, FL, USA, 19-21 May 2009

DGA

DÉLÉGATION GÉNÉRALE POUR L'ARMEMENT

Centre d'Etudes de Gramat
BP 80200
F-46500 GRAMAT

Jean-Marc Sibeaud

Area of activity

- CEG is Technical Center of the French MoD procurement Agency (DGA)
- Expert center for **Terminal effectiveness** of Conventional Air-to-Ground weapons and missiles

- Gives support to program managers for weapons or components development (SCALP/EG missile, AASM PGM, MdCN Navy cruise missile, FBM 21 fuze for air delivered munitions)

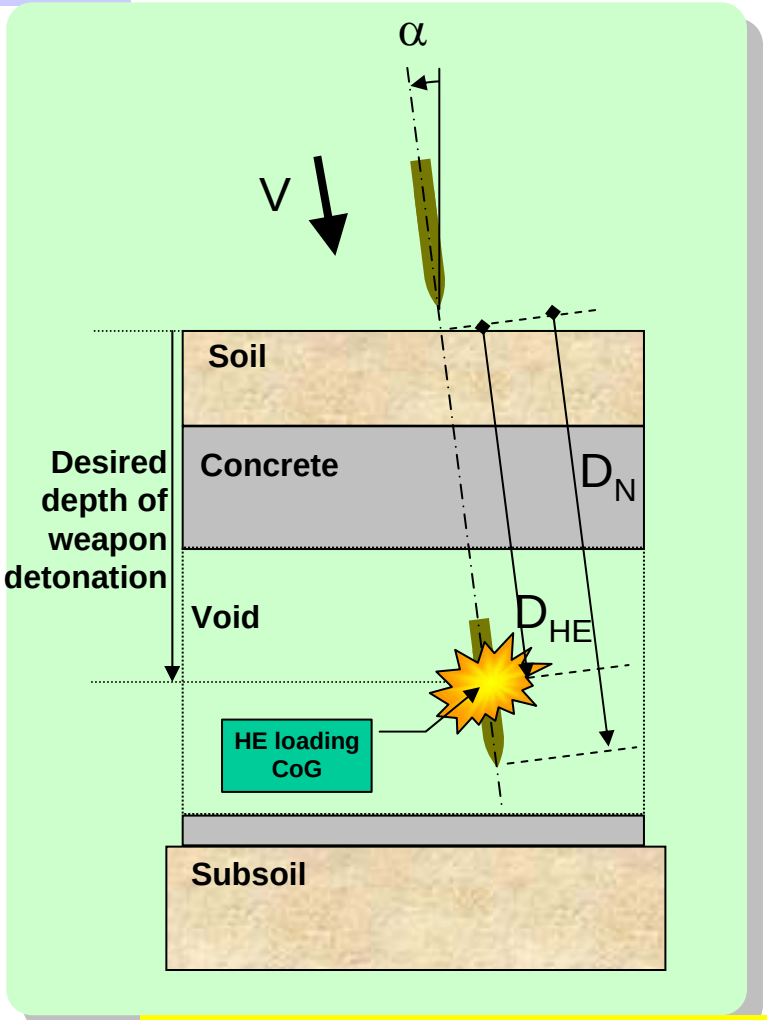
- Provide *Armée de l'air* and *Aéronavale* (French Air Force and Navy Air Force) with means for determining effectiveness of strikes and perform mission planning

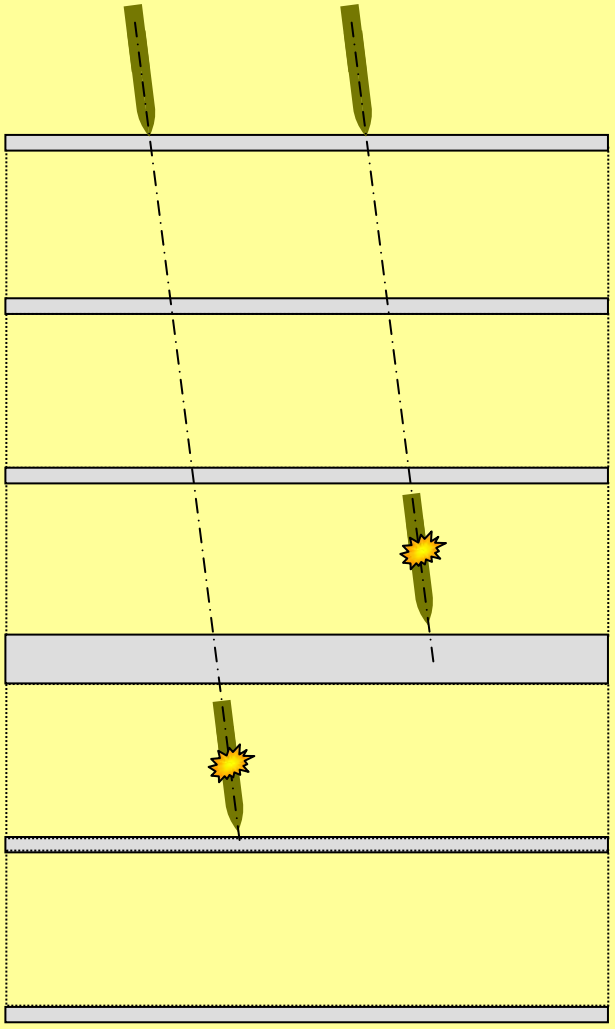
- Anticipate on threat evolution

Next generation fuzing will make use of embedded intelligence

- Hardened targets (Hard target defeat) and soft targets
- Objective: Improve warhead lethality while minimizing collateral damage
- Capability to control weapon's depth of burst and eventually full trajectory

Hard and soft targets defeat: optimal fuze delay depends on target and weapon parameters

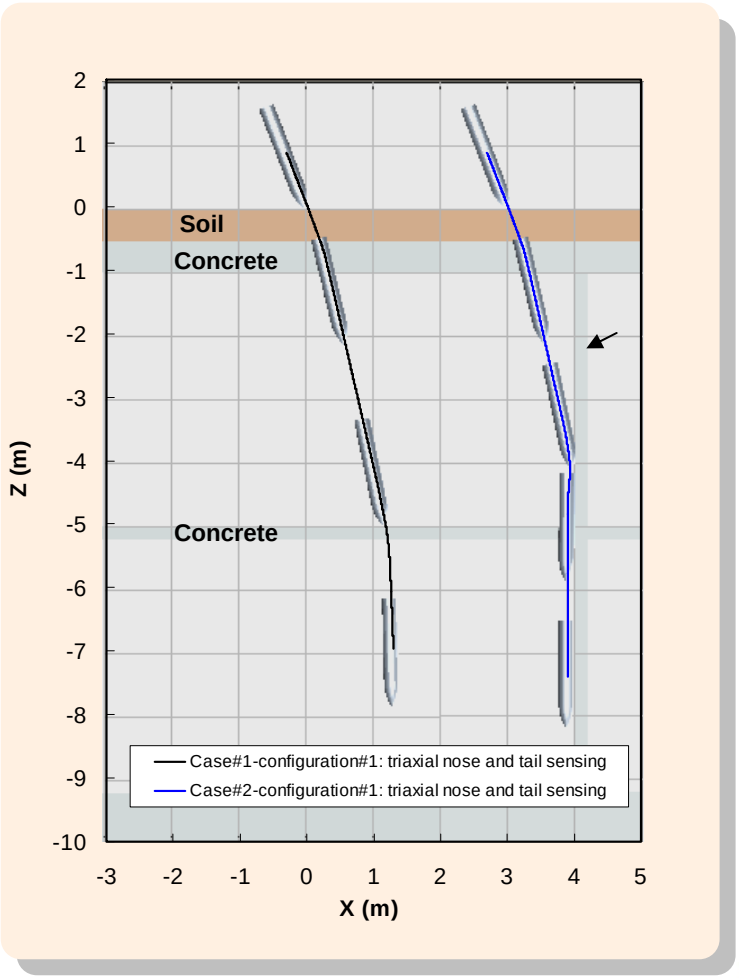




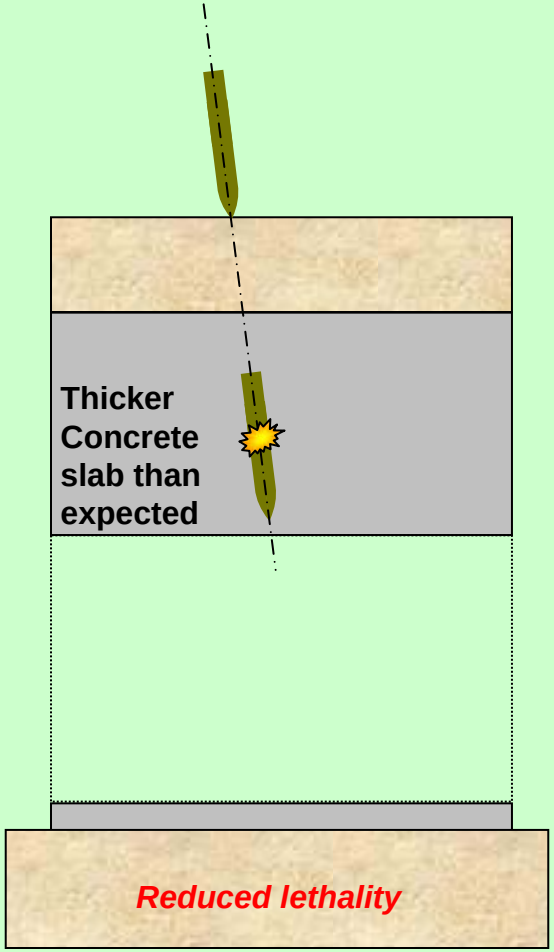
maximum lethality if point of detonation located at the right place

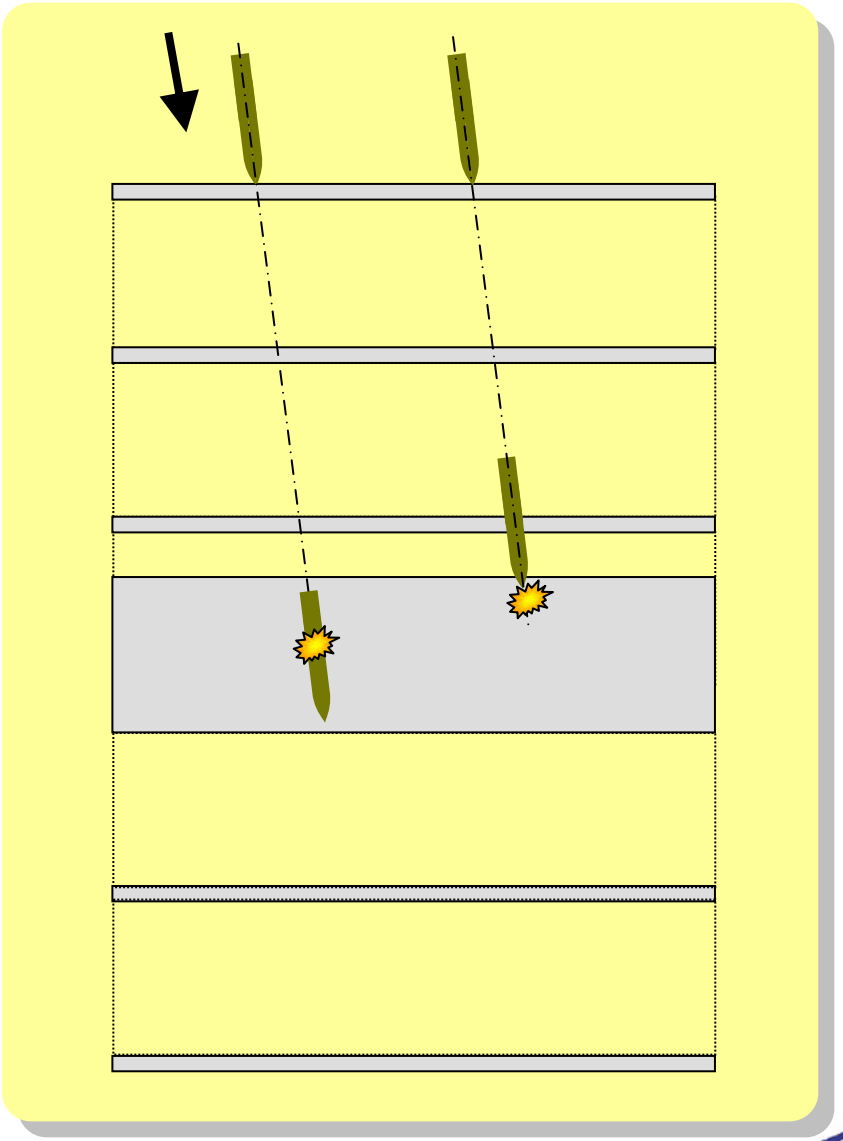
Validated analytical and computational tools exist to help predict the fuze delay for a given mission

- CEG and the French targetting Center operate the CalPen3D analytical program that computes the curvilinear trajectory of the weapon within the target
- The fuze delay is therefore accessible to the mission planner



Hard target defeat: unexpected situations using a constant fuze delay





Smart fuzing

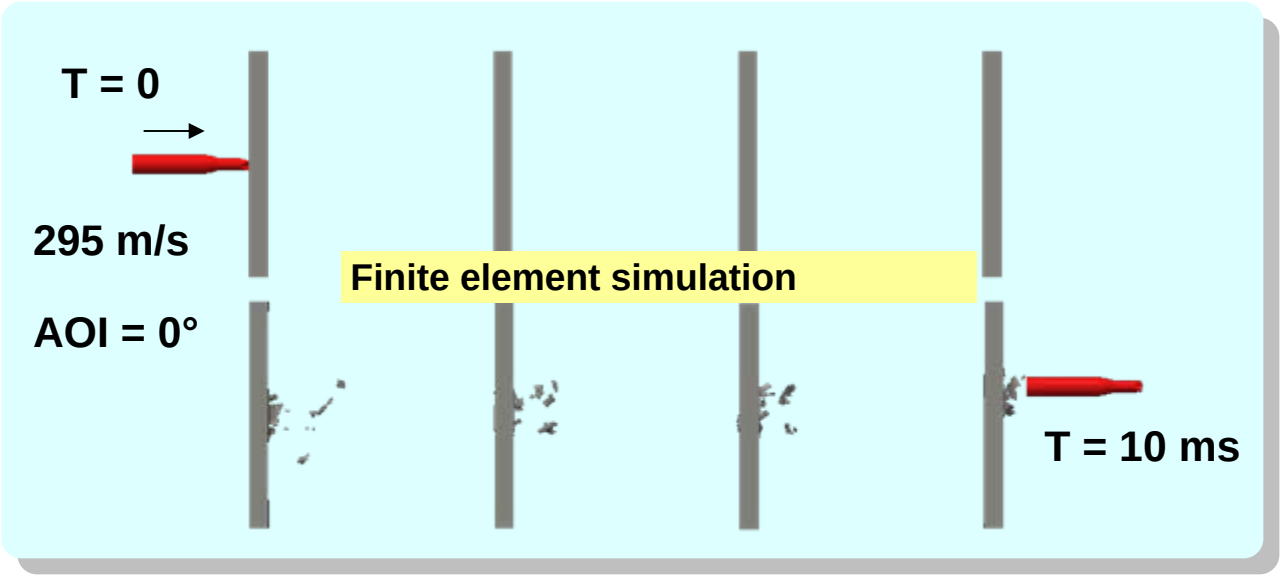
- The munition analyses its environnement and triggers the HE charge when conditions are met
  - Void sensing
  - Layer counting
  - Trajectory calculation
- In this latter option, the warfighter specifies the point of detonation instead of a fuze delay

⇨ High-G sensors, rugged electronics and complex algorithms must be developped and integrated

An illustration of the possibilities and challenges: perforating of spaced concrete plates with a model scale projectile

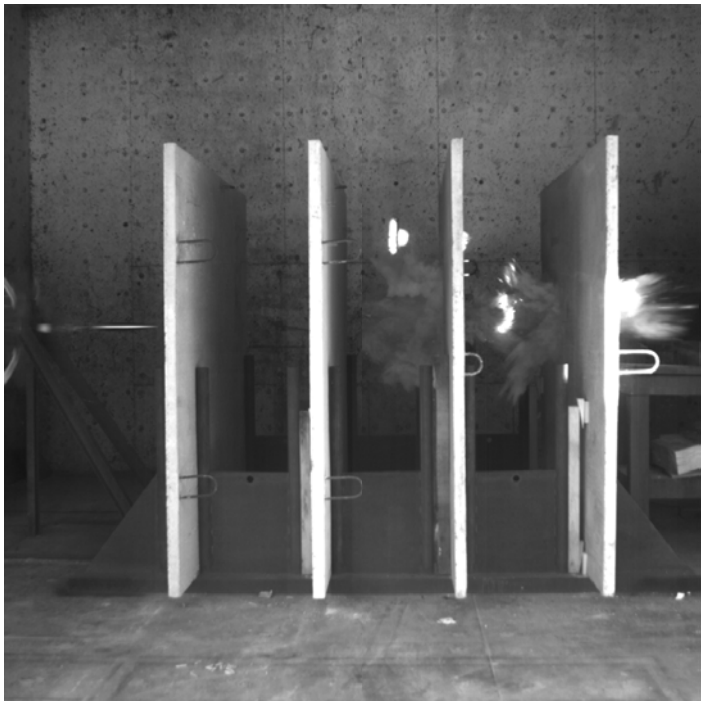


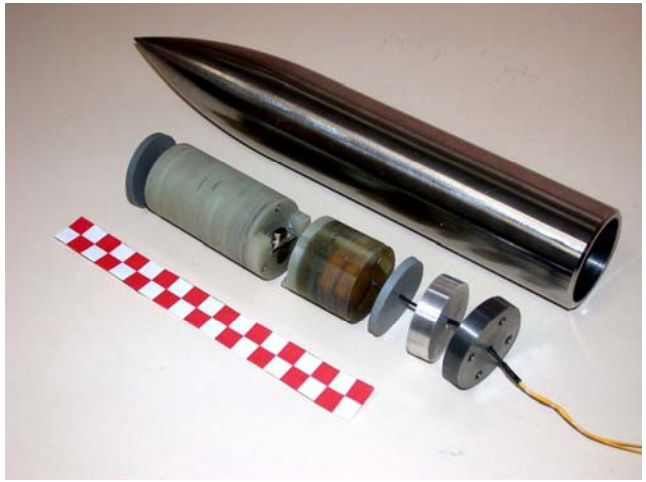


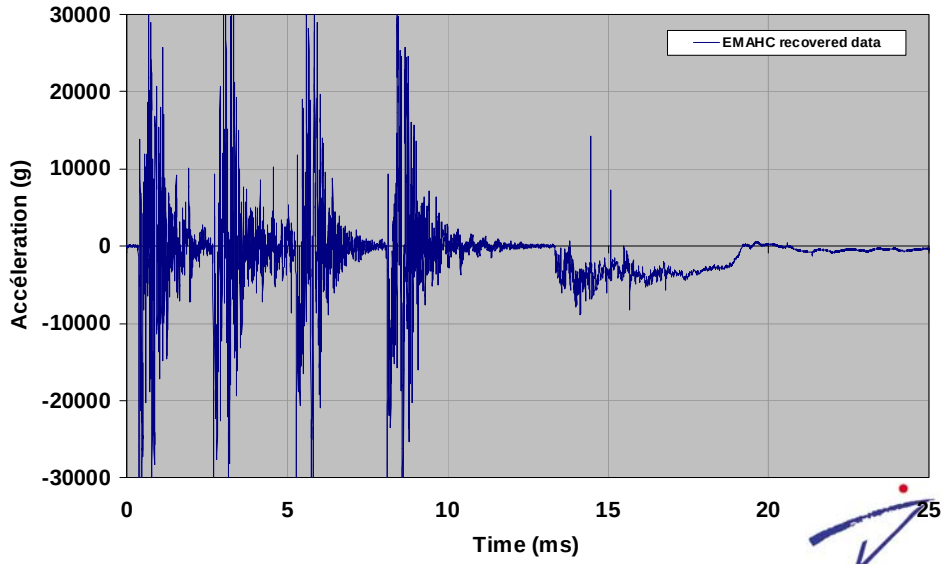


Presentation of the EMHAC High-G recorder and Experimental result

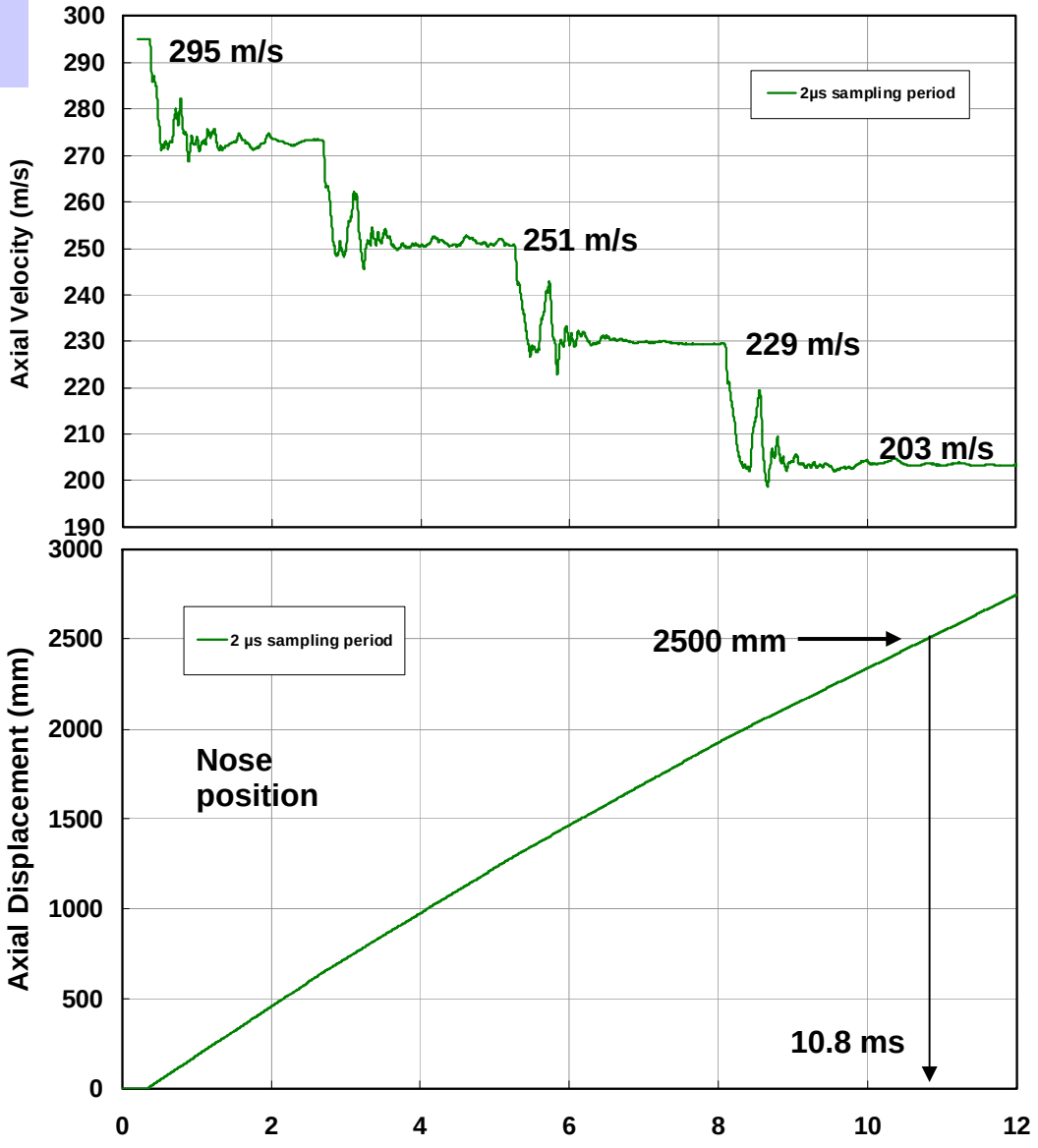
- Triaxial T2M-Junghans Shock datta recorder
- Range of data acquisition ± 20 kGs (Channel X1) ; ± 60 kGs (channels X2, Y, Z)
- Storage duration : unlimited (FLASH memory)
- Sensors : Endevco Accelerometers
- Sampling rate : up to 500kHz (4-channel) or 1MHz (2-channels)
- Memory size : 256 M samples
- Reusable







Double integration of signal



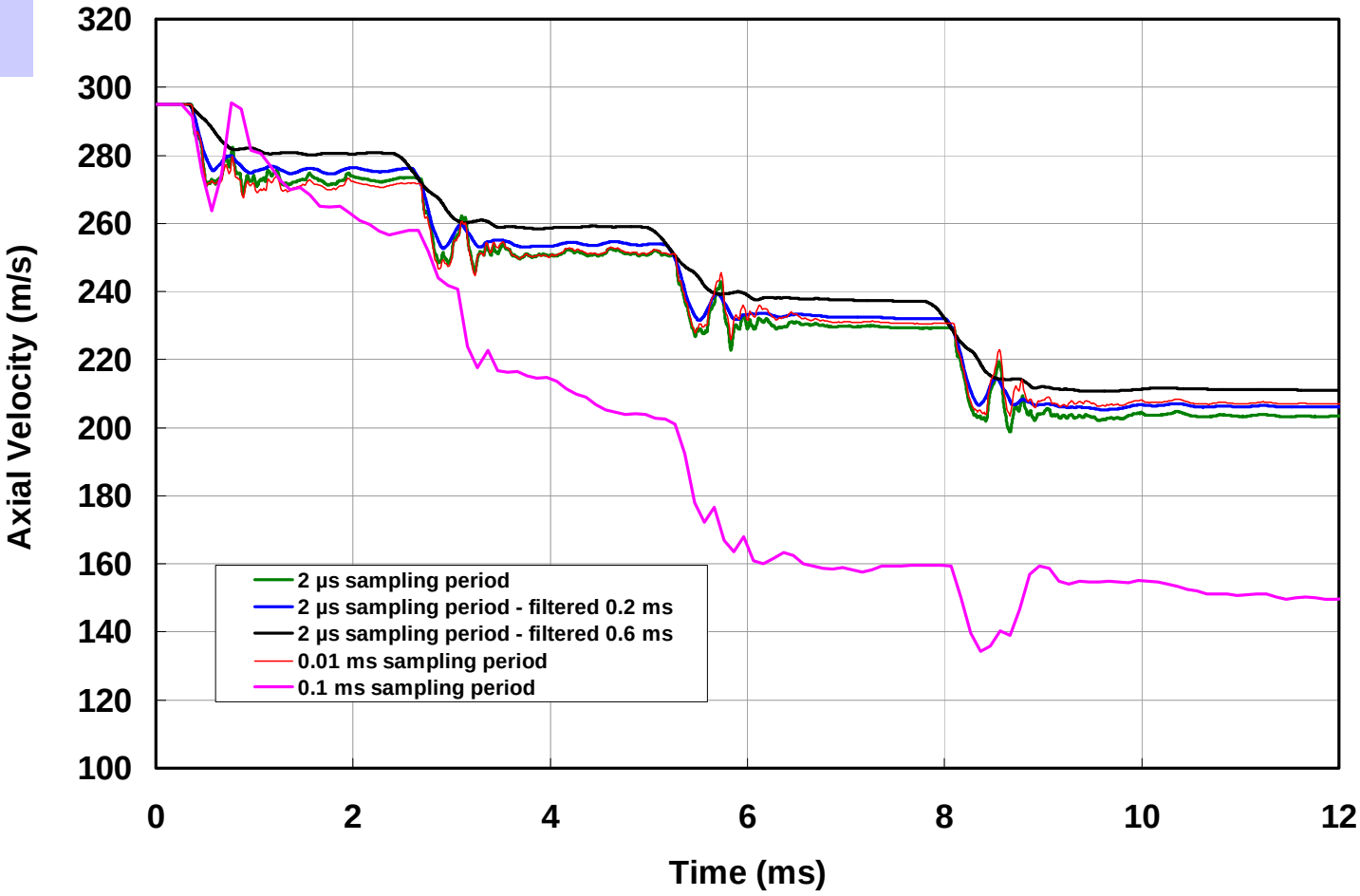
… provides continuous velocity and displacement time histories

prior knowledge of initial conditions (velocity) is required

⇨Smart fuze development would require knowledge of initial conditions (velocity)

⇨Must be transferred from weapon guidance system

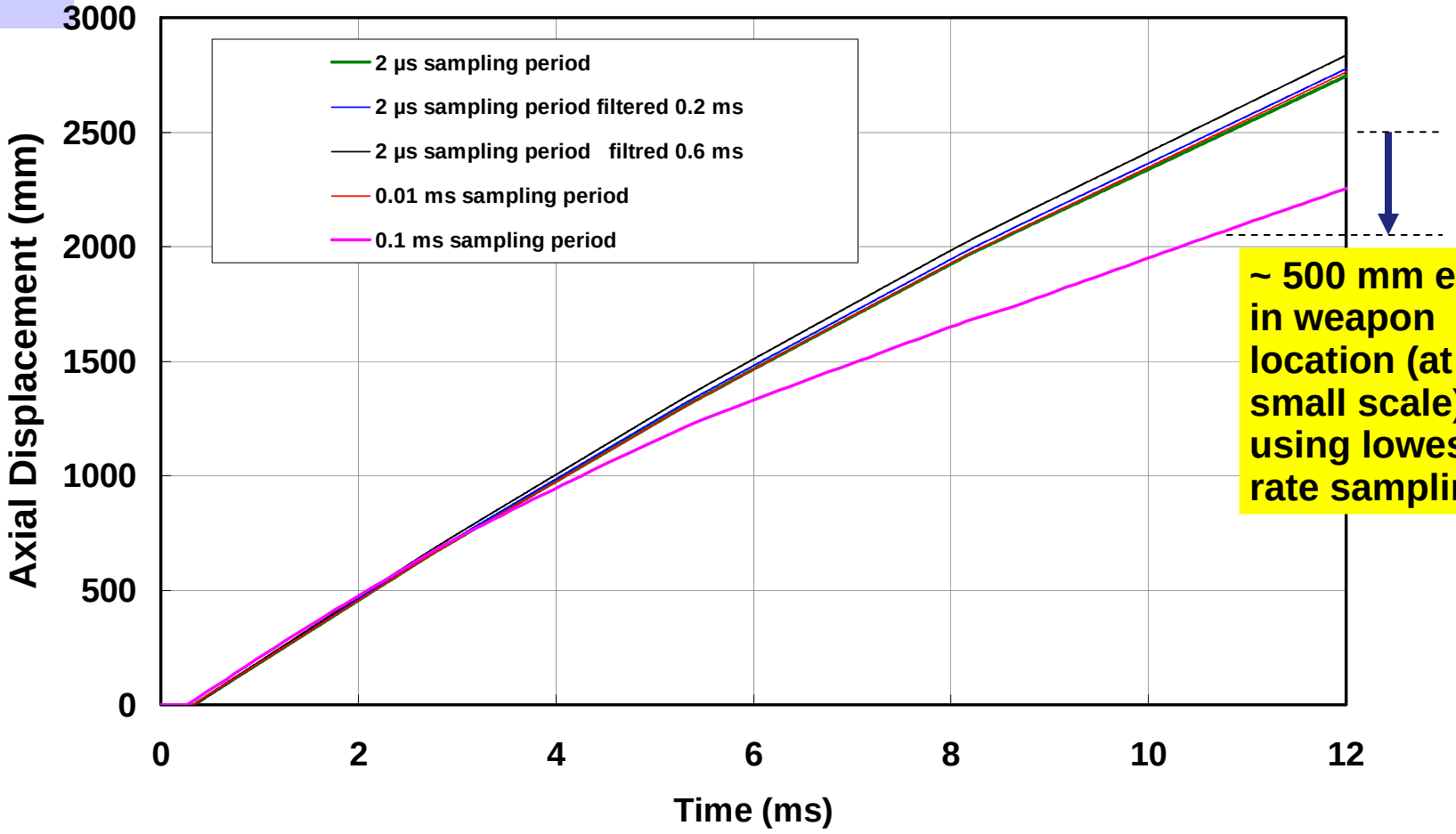
Influence of sampling rate and filtering on velocity



⇨**Consistent velocity prediction requires minimum sampling rate (at least 100 kHz or one sample every 0.01 ms)**

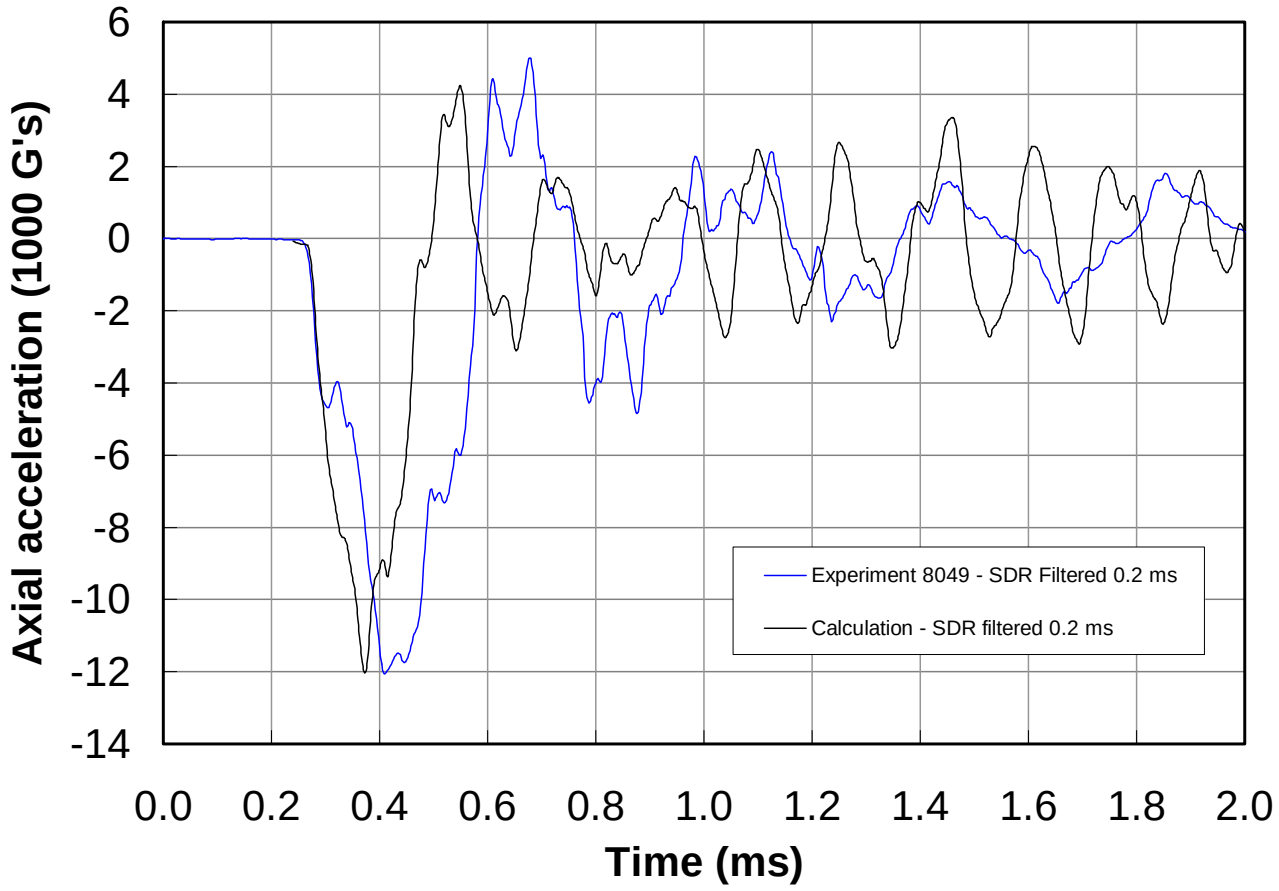
⇨**Filtering of acceleration signal has marginal effect on velocity determination**

Influence of sampling rate and filtering on location



⇨ **Prediction of displacement highly affected by sampling rate**

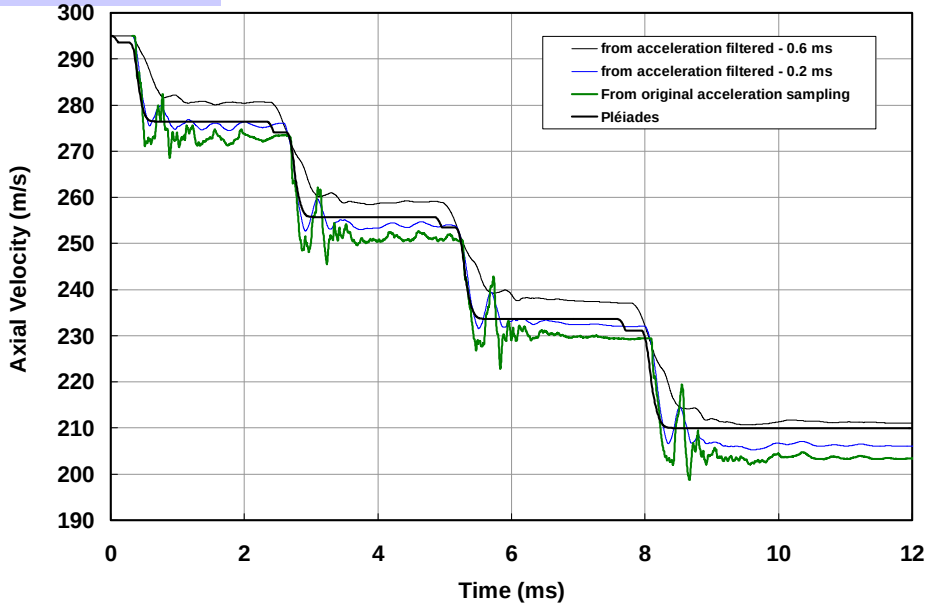
Numerical simulation capabilities in order to better understand process

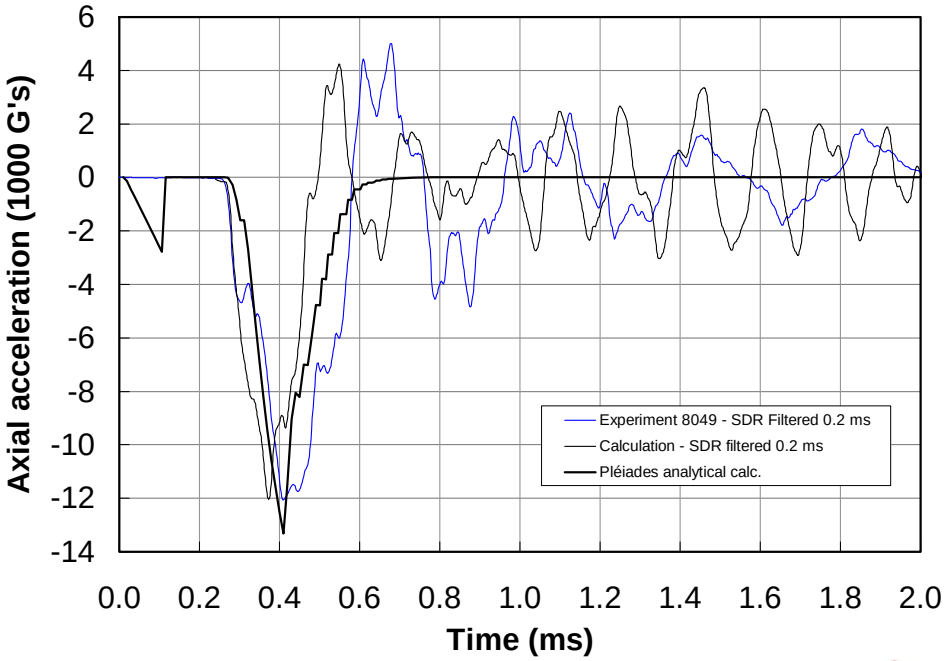


⇨ **FE calculation result match reasonnably well data (both filtered similarly)**

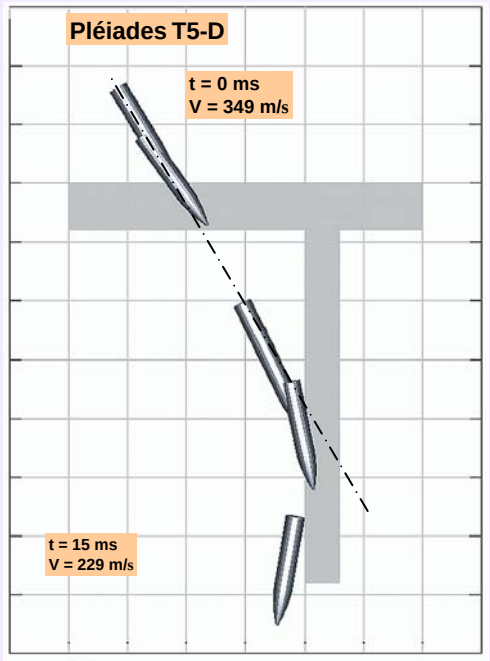
FE prediction need to be improved in order to reduce frequency mismatch (eigen modes of model must be monitored)

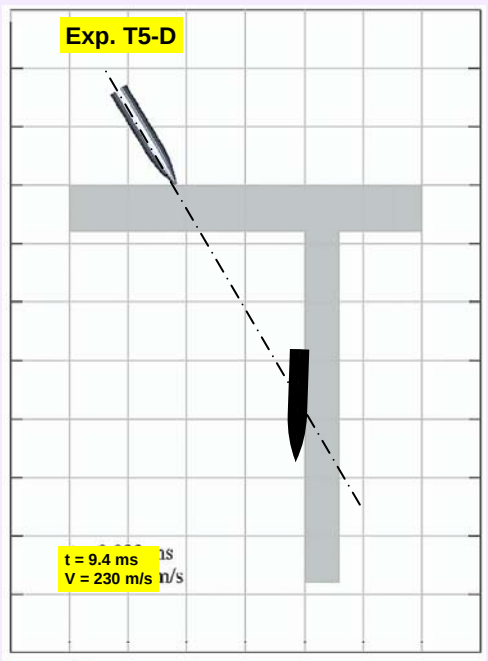
Analytical modeling (CalPen curvilinear calculation of projectile trajectory within the target)





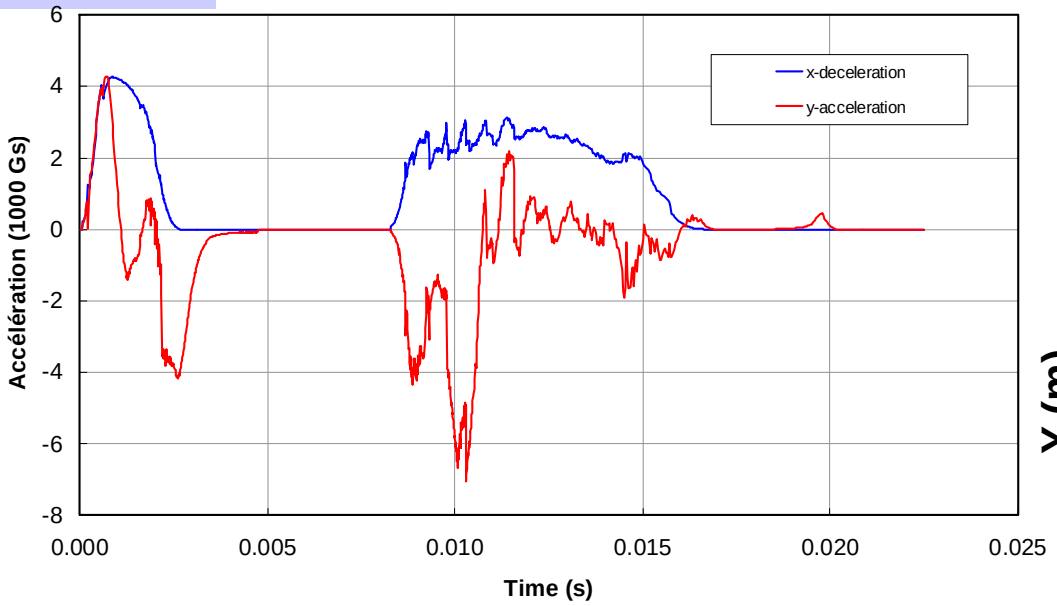
Next step : analysis of a plane trajectory using experiments at scale 2/3 (see Fuze 52 paper)

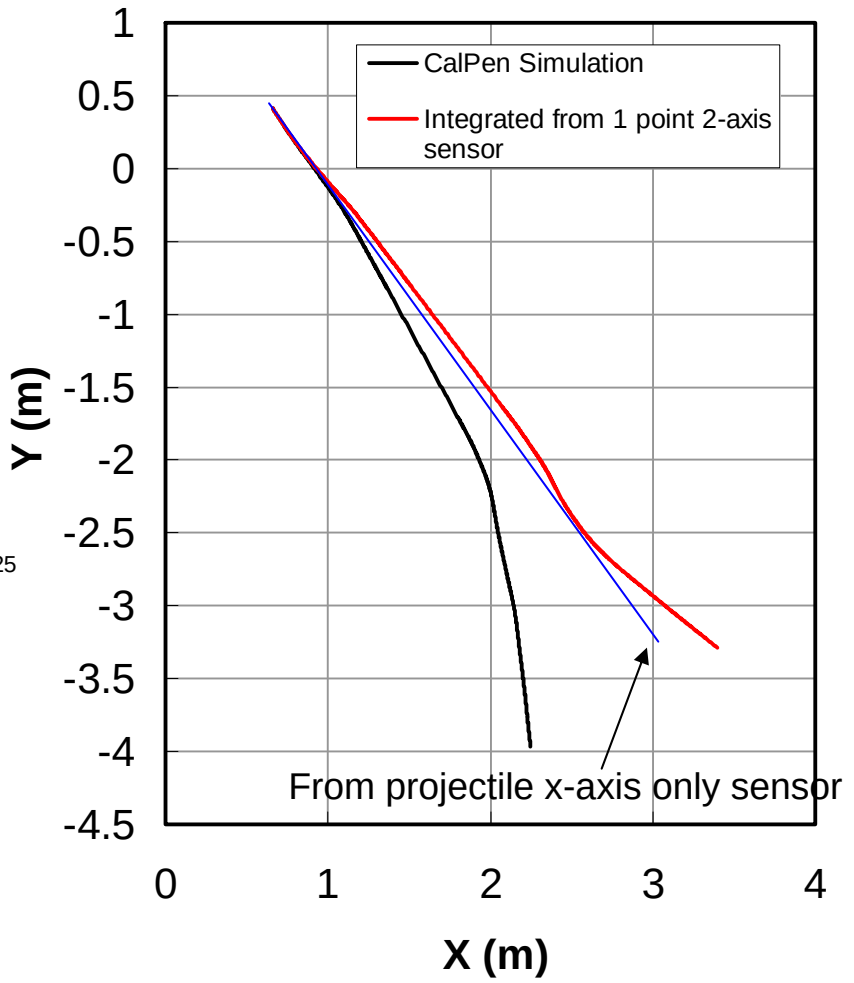




- Assumption : plane trajectory
  - 1 sensor – 1 axis
  - 1 sensor 2 axis (longitudinal (x) and transverse (y) of projectile)
  - 2 sensors 2-axis per sensor

T5-D configuration - 2 sensors –2-axis

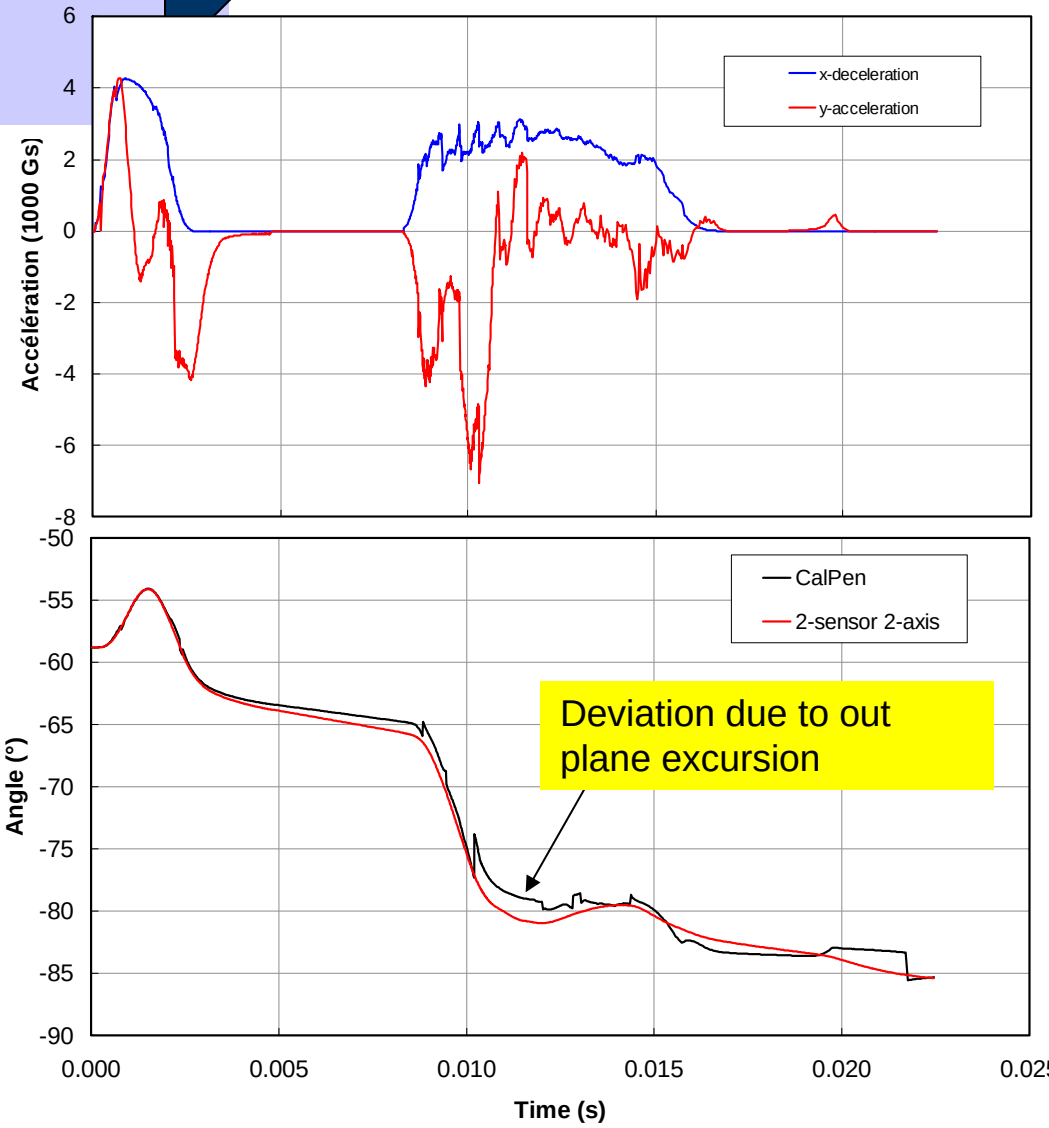


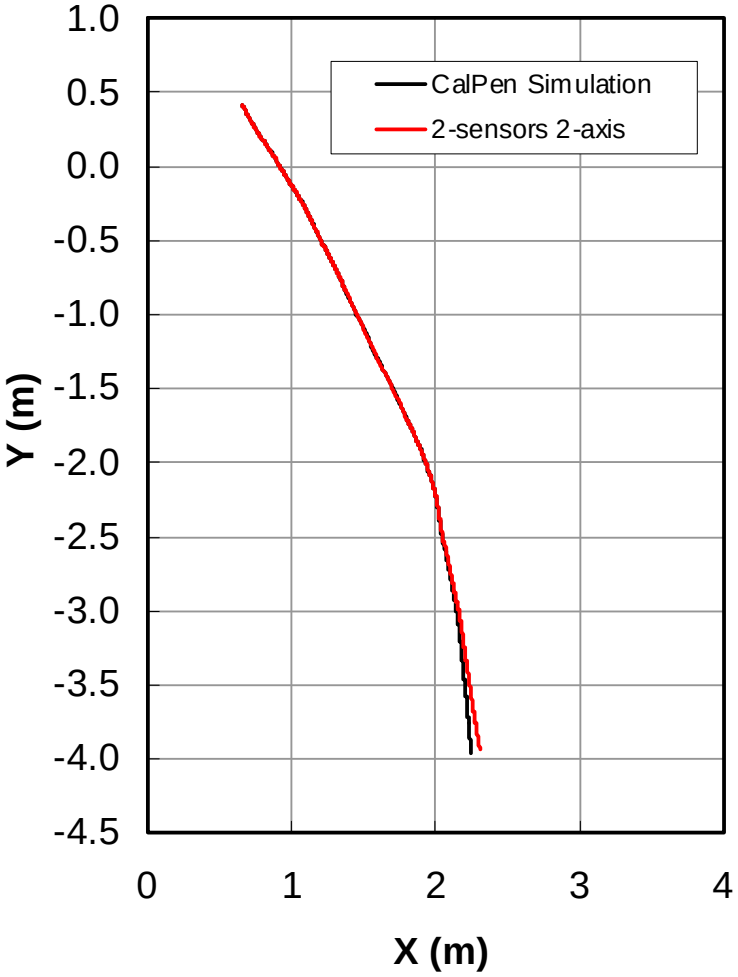


Single axis sensing performs well provided that initial direction of munition is given

If this data is not available integration of x and y strapdown signals provide the expected trajectory and depth. Error appears important because of ricochet of munition on vertical wall cannot be interpreted by a single point sensor

T5-D configuration - 1 sensor – 1 and 2-axis





Angle between projectile and inertial coordinate axis can be calculated and therefore inertial accelerations from which velocity and position are derived

Accurate if trajectory is plane

General case : curvilinear trajectory

- To be developed and hopefuly presented at the 54th annual Fuze Conference

Conclusion

- Shock data recorder provides invaluable information for penetrator trajectory analysis and identification of challenges posed by smart fuzing for Hard target Penetration applications

- Three channel Shock data recorder currently investigated

- Use of multiple miniature G-hardened sensors may allow inertial measurement to be done and therefore a precise determination of the detonation point in the target core

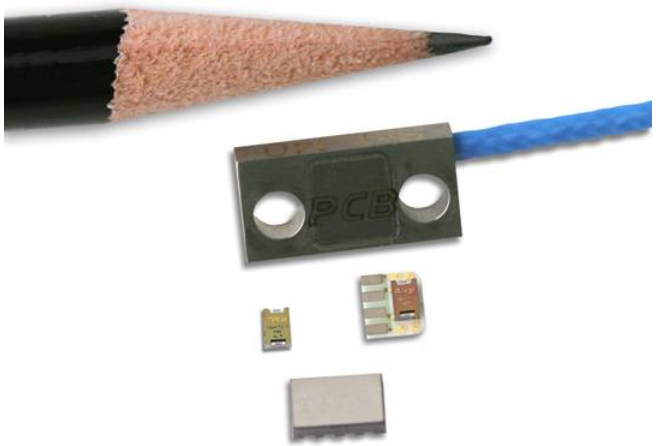
MEMS Shock Sensor Field Results Using Alternate Packaging

Robert D. Sill
Senior Scientist
PCB Piezotronics Inc.
951 Calle Negocio, Suite A
San Clemente CA, 92673
rsill@pcb.com (877) 679 0002 x2954

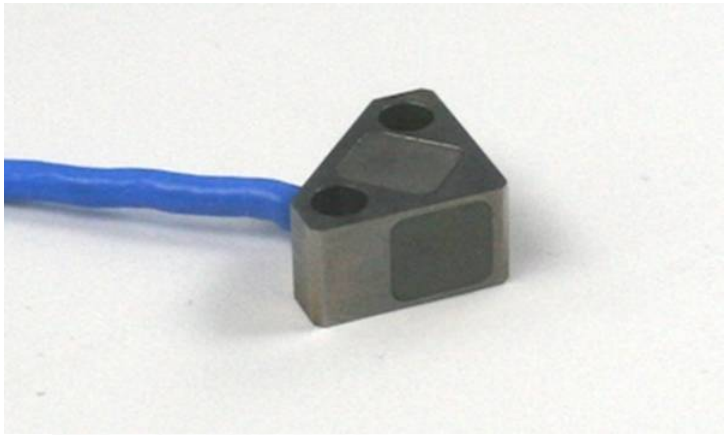
May 2009

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Introduction



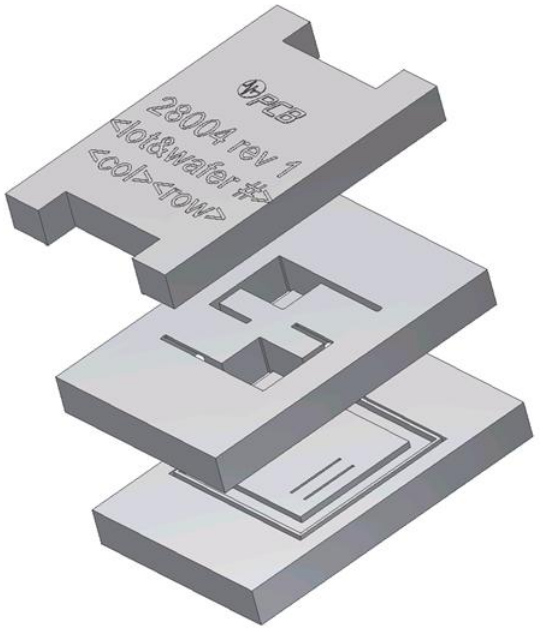
- Description of MEMS sensors
- Alternate packages
- Test results
  - Hopkinson bar in thermal chamber
  - 30kG for triaxial package
  - >100KG for ¼-28 stud package
  - Surface mount package at high speed penetrations through concrete
  - Metal-on-metal impact test of ¼-28 stud package
  - Low level pyrotechnic



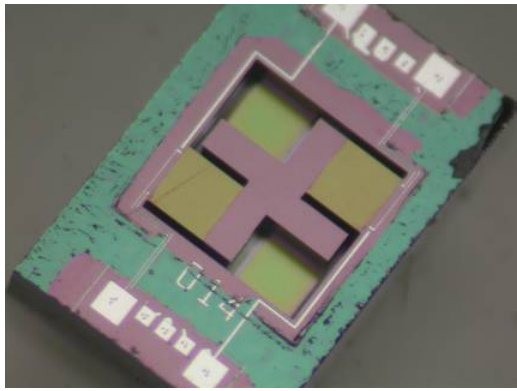


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Sensor Description



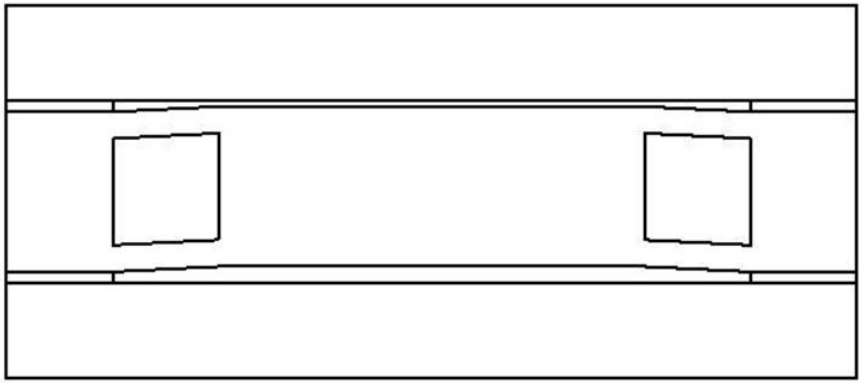
- Fully active bridge piezoresistive shock accelerometer.
  - First implementation is 20KG full scale.
  - 60KG now in fabrication
- ~5000Ω Input Resistance for low power consumption
- Ion implantation on one side only
  - Low ZMO (Zero Measurand Output), or bias
  - Low Thermal Zero Shift
  - Low power-on warm up drift
- Wirebond pads can be solder-bumped for “flip chip”



Sensor Description (cont)

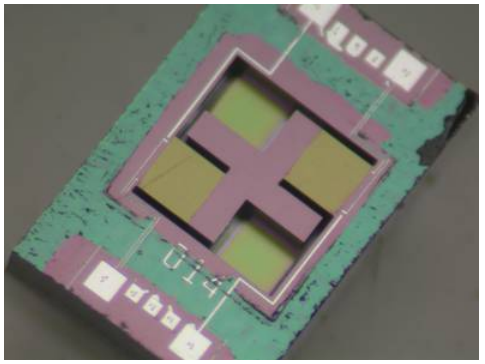


- Diced from a sandwich of three wafers
  - Sensors are hermetically sealed
  - Thicker cantilevers for higher range
- Intentionally low resonance (~65kHz)
  - Frequency response matched to application



- Relatively large displacements enables:
  - Squeeze-film damping, from air trapped in gap, to reduce resonant amplification
  - Over Range protection if displacement is similar to gap to Lid and Base layers

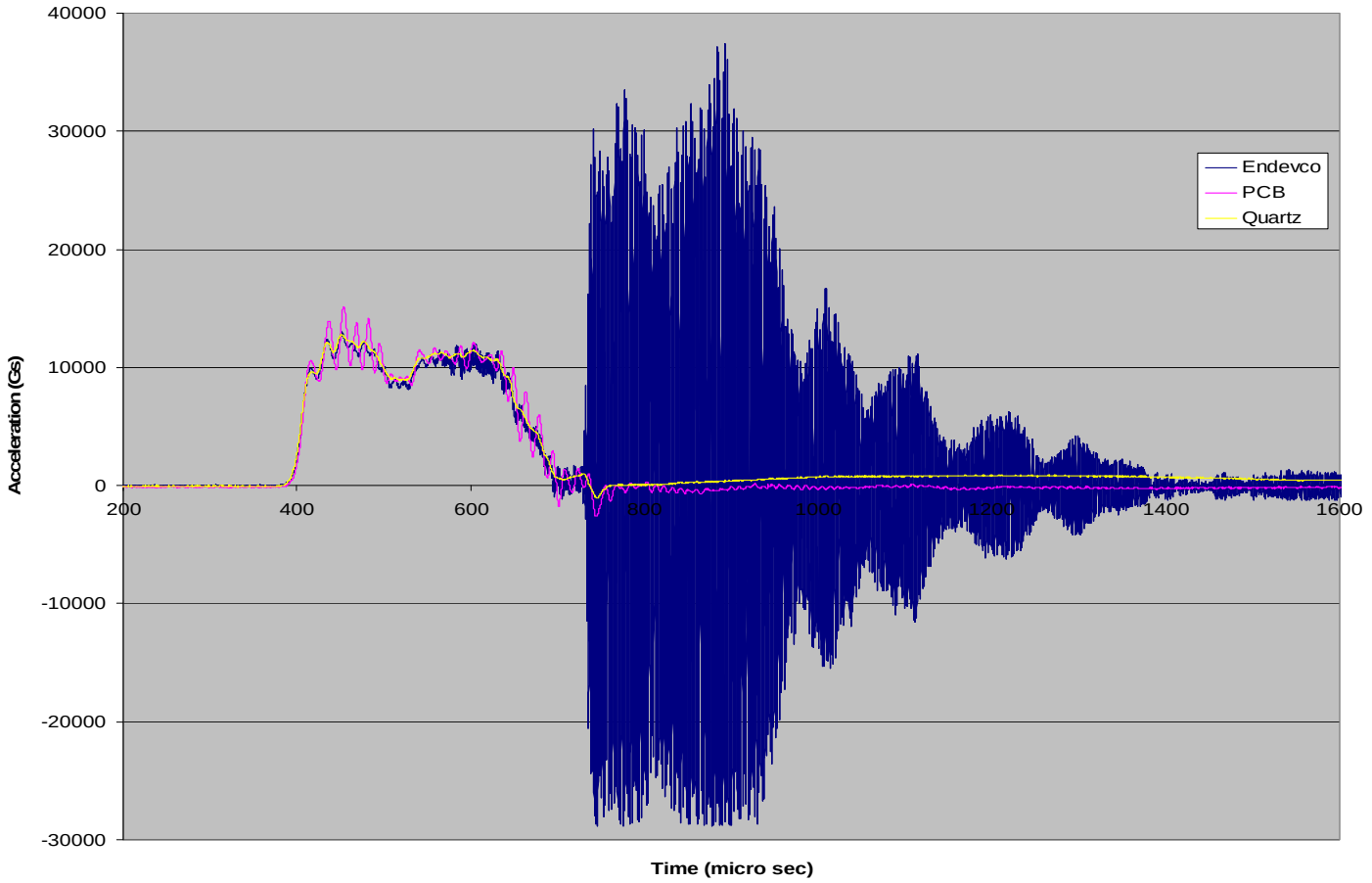
Higher Range (60kG) Sensor



	data for 20kG version	estimates of 60kG
Sensitivity	1uV/V/G	0.3uV/V/G
Full Scale (20mV/V)	20kG	60kG
Resonance	~65kHz	~120kHz
Mechanical stops	+/- 40kG	+/- 100kG
Resonant amplification "Q"	~10	~30
	other parameters are the same for both versions	
Input Resistance	~5000 Ω	
ZMO	<2%FS	
"Flip chip" capable?	yes	
Dimensions	0.098" x 0.067" x 0.039" (2.5mm x 1.7mm x 1.0 mm)	

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Effect of slight damping



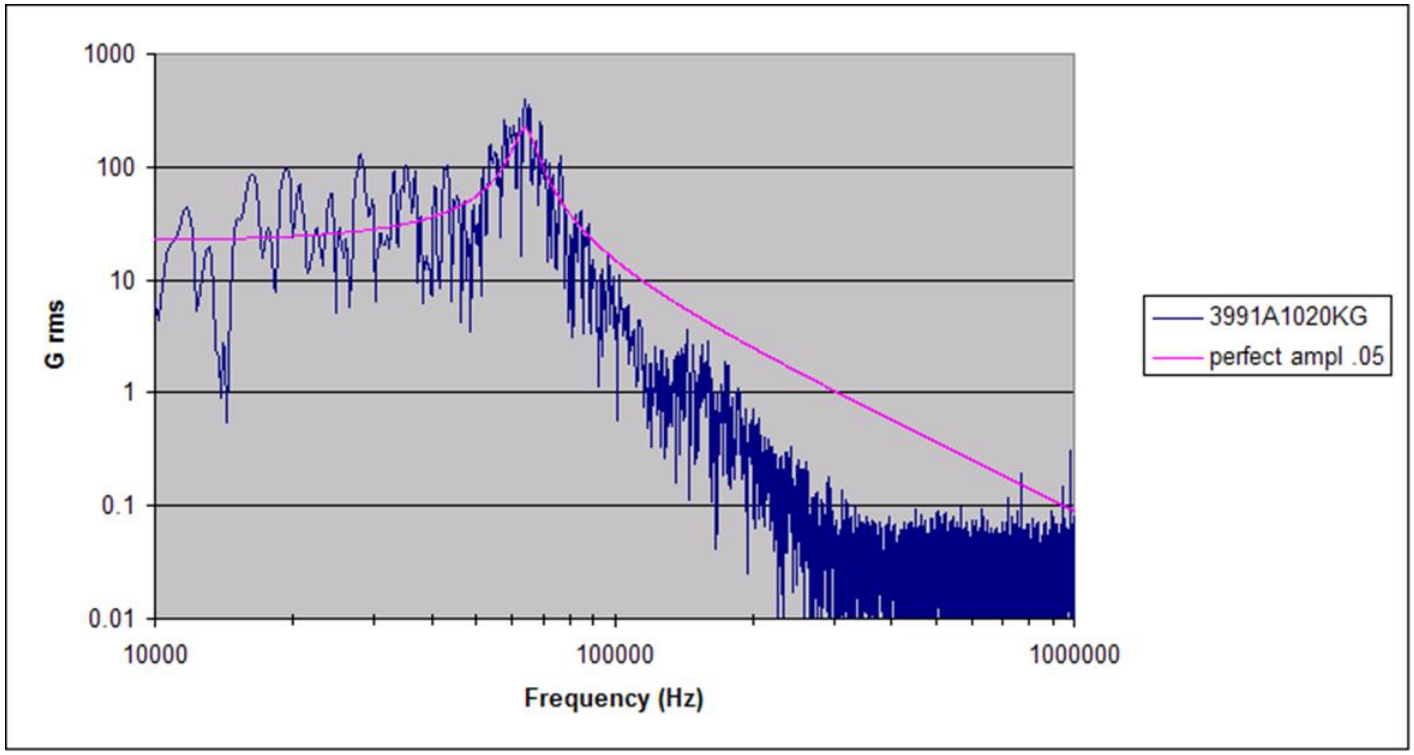
In low level Hopkinson bar tests the new sensor showed some low Q resonant amplification during the initial pulse, and the undamped legacy sensor (20kG) showed extremely high Q response after the fixture broke away from the bar.

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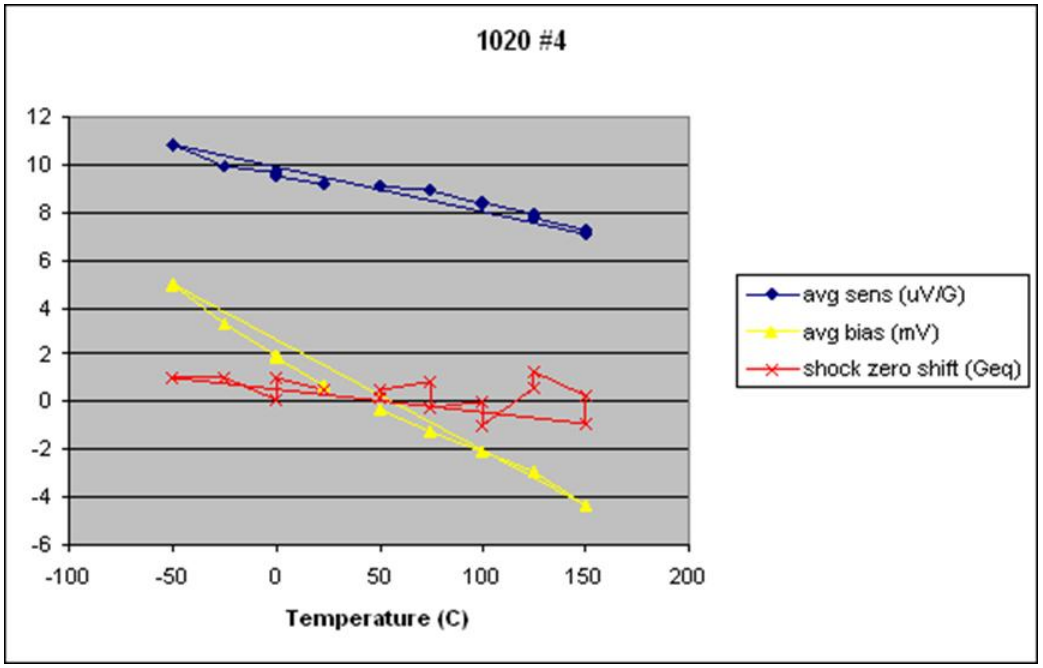
Effect of slight damping (cont)

Sensor has 65kHz resonance and 0.05 damping. Overlaying a perfect sensitivity curve on the hammer test FFT shows the damping may be more effective than expected at frequencies higher than the primary resonance.

Associated with the damping was a phase delay of ~4 microseconds.



Thermal characteristics



From -50C to 150C, these parameters were measured on a Hopkinson bar:

- Sensitivity at 20KG
- Bias
- Zero shift at 20kG and 50KG (attached to bar)

Packaging Alternatives

- With the“flip chip” modification, the sensor can be directly mounted to a circuit board.



- Surface mount triaxial block for flip chip sensors, with internal pad connections, would enable significant miniaturization.

Test Results – Penetration

- Using Surface Mount single axis package

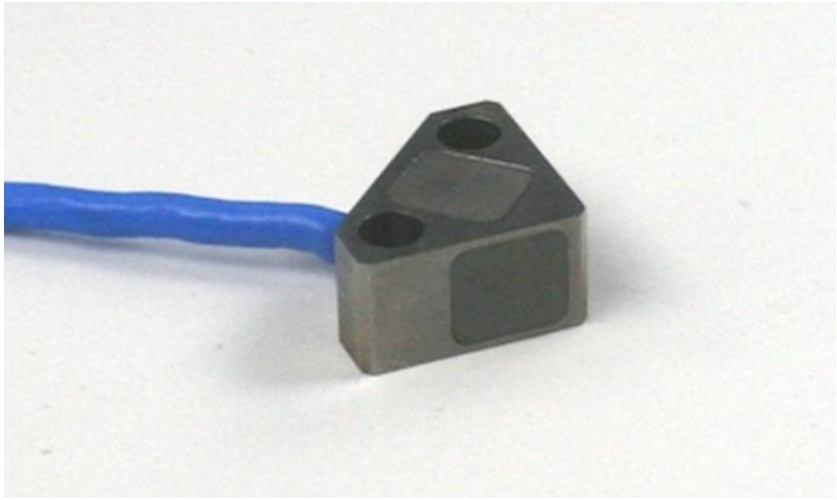


- Gun launch at high speed, with unspecified penetration event
  - "the most severe" performed at that facility
  - Resistance and Bias measured before and after, no change detected
  - Another user announced data from a "faster" event

Other Packaging Alternatives

- Triaxial

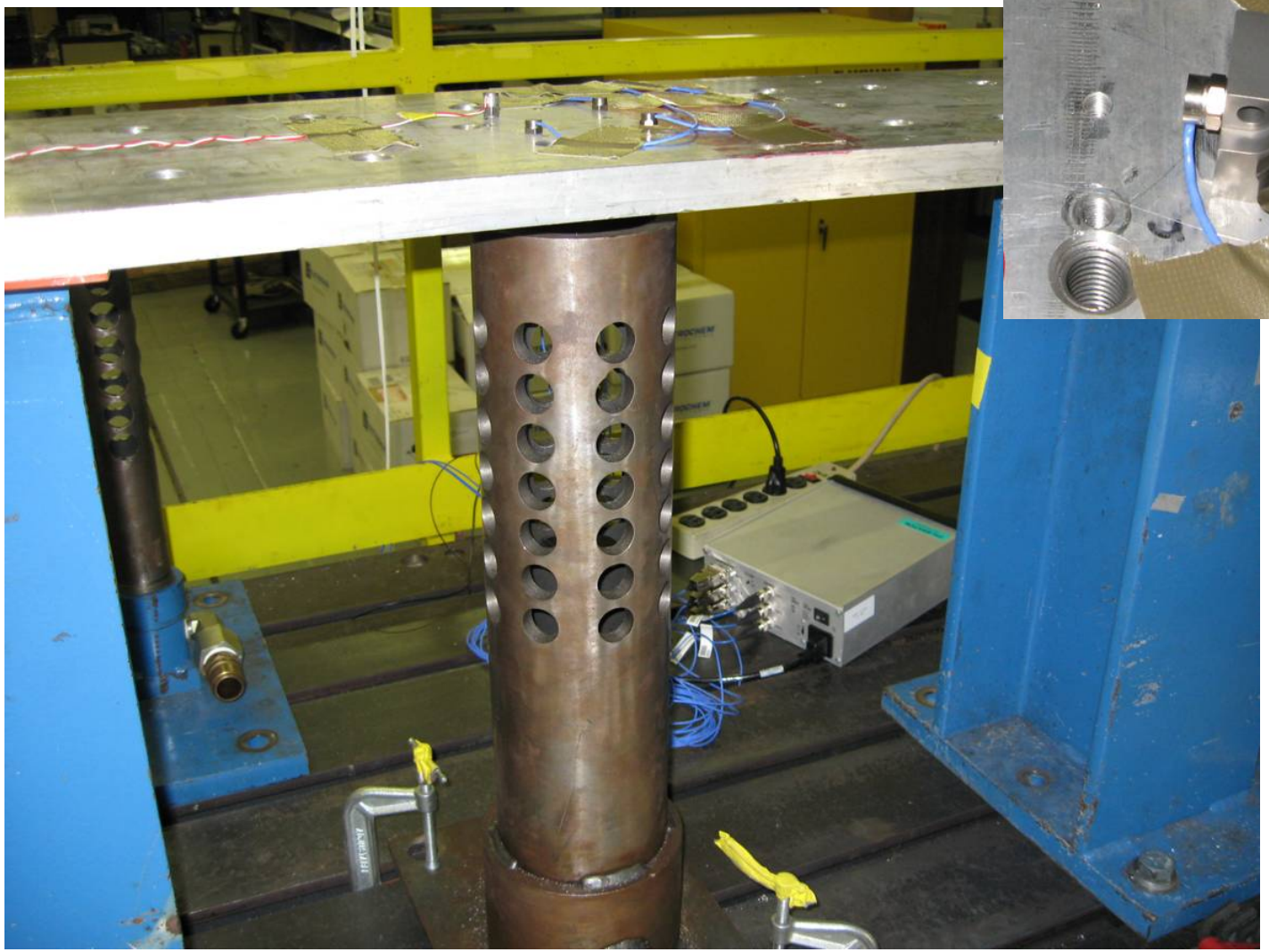
- Single axis packages are intended for metal-to-metal impact and pyrotechnic applications





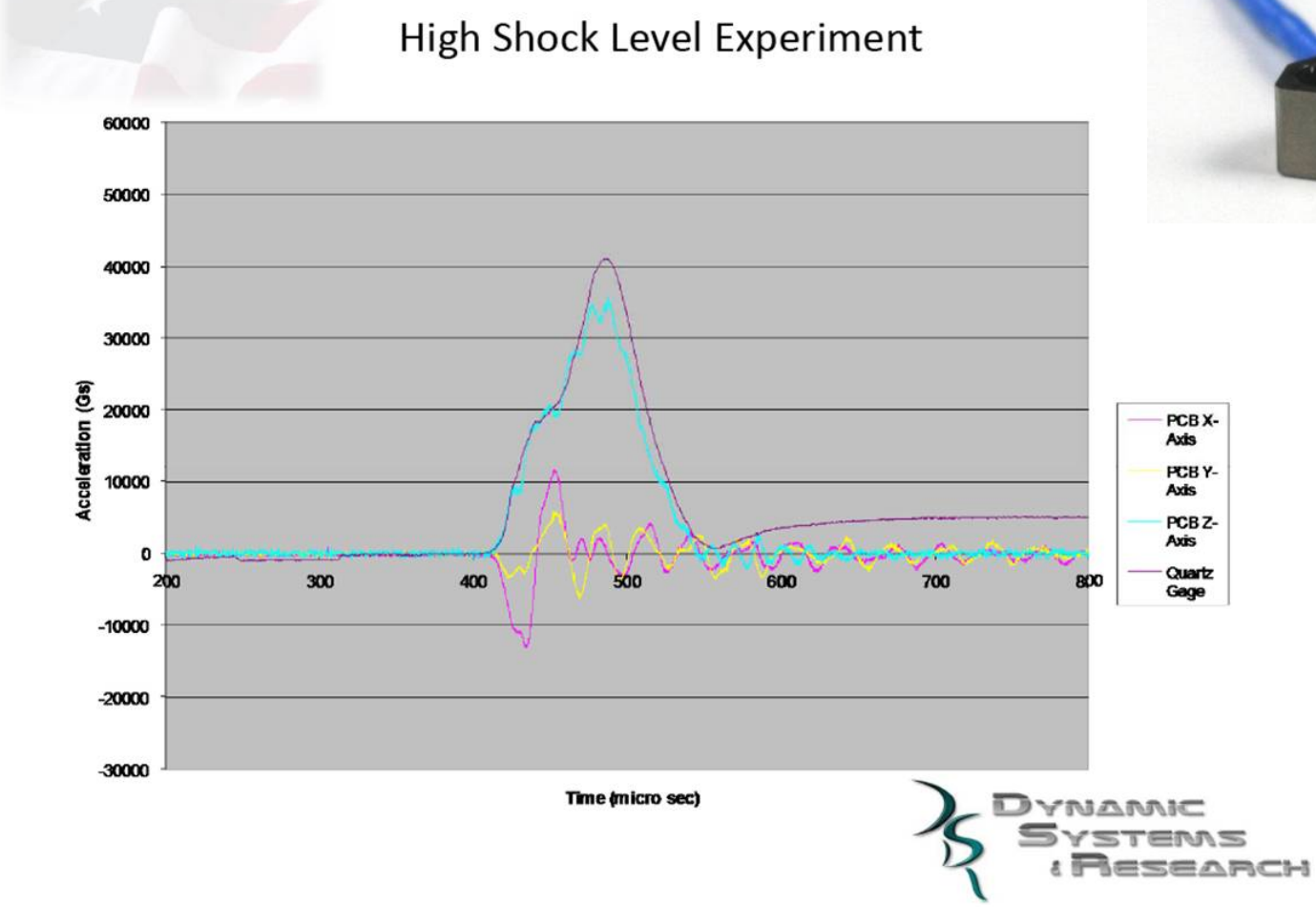


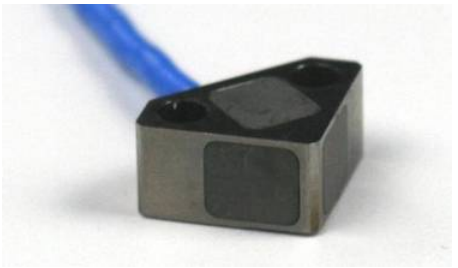
Test Results – Metal-to-Metal Impact



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Hopkinson Bar Triaxial Test

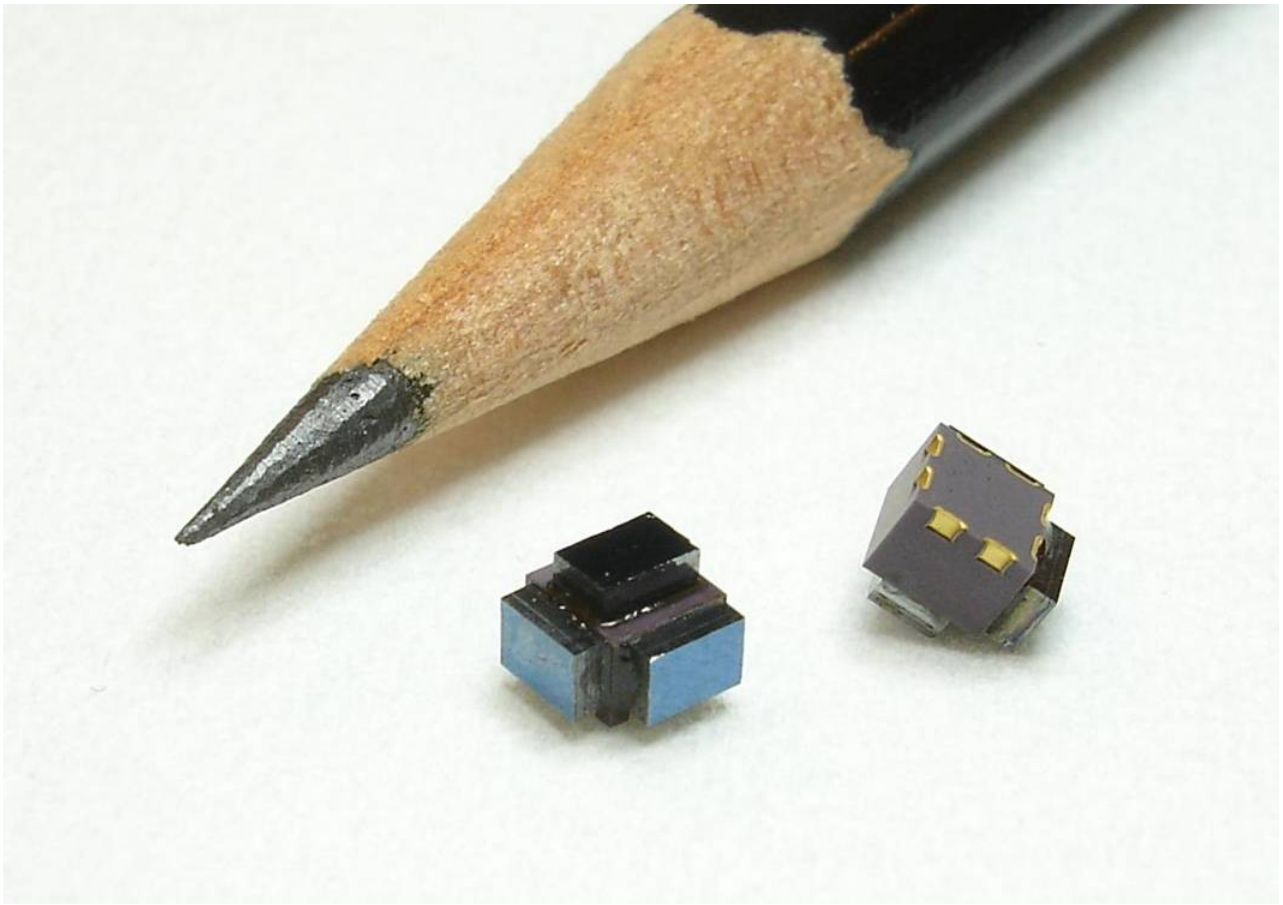




- Data courtesy of D. Frew, Dynamic Systems and Research

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Surface Mount Triaxial



- Now preparing substrates and test hardware

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Conclusions

The Leadless Chip Carrier (LCC) surface mount package has survived and performed acceptably in

- Hard target penetration in three successively higher velocities

Flip chip

- Field tests have not yet been completed for single axis nor triaxial configurations
- Allows smallest footprint

¼-28 package

- Metal-to-metal
- Successful at low level pyrotechnics
- The new 60KG sensor soon will be ready for higher level tests